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NEW SEED DISINFECTANTS FOR THE CONTROL OF BUNT OF WHEAT AND THE SMUTS OF OATS AND BARLEY

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With Plates XXV to XXVIII

INTRODUCTION

The subject of seed treatment is one on which a large amount of investigation has been done. Yet it is a subject decidedly in need of further thorough and critical study. There is a striking need for disinfectants which will control seed-borne diseases and at the same time cause no injury to the treated seed. This demand has led scientific investigators and commercial organizations in the past to develop and study numerous chemical substances and compounds with the hope of finding something satisfactory. Of the several preparations tested, the great majority have proved worthless; others have limited use; while a few, including formaldehyde and copper-sulphate-lime, have proved of sufficient value to bring them into extensive use. However, seed treatment has not been practiced as generally as the needs would seem to demand. This is true in the case of certain of the cereal smuts which are comparatively easily controlled. One of the reasons for this lies in the fact that more or less seed injury often is caused by the generally recommended formaldehyde and copper-sulphate-lime treatments. Too often these complaints of seed injury have been explained away on the basis of improper preparation or handling of the treatment. It is now known that many factors may influence the effects of the treatment on the seed. Among the more important of these factors, not including variations that may occur in the material, its preparation and its application, are the kind of seed, the particular variety treated, the conditions under which the seed is grown and subsequently handled, and the local soil and weather conditions existing where the seed is sown after treatment. As these various limiting factors have made it almost impossible, even for the expert, to obtain satisfactory results with the treatments in use, there has been a keener interest in the search for disinfectants which are not

injurious to the seed, at least within reasonable limits, as to strength of material and time of application. During the past decade investigations of this kind by both scientists and commercial organizations have become very intensive. Out of these studies a few materials of importance and promise have evolved. The more important of these are copper carbonate, the effectiveness of which is thoroughly established for the control of bunt in wheat, and some of the organic mercury compounds.

The object of these investigations has been to test these new compounds in comparison with the standard treatments, with the hope of finding something of greater value for the control of cereal smuts and other seed-borne diseases. The data presented herein necessarily are fragmentary, owing to the fact that some of the materials were not available during all years, while others were discarded as soon as they were found valueless.

HISTORY

The literature dealing with the new materials, especially the mercury compounds, is becoming so voluminous that it is not desirable to attempt to review all of it in this paper. Chlorphenol-mercury, the basis for such commercial preparations as Uspulun, Chlorophol, and Semesan, was used in Germany (9) for the control of bunt in wheat as early as 1912, if not earlier. The favorable results reported by Riehm at this time and one year later (10) no doubt led to the commercializing of this material under the trade name "Uspulun." In 1914, Remy and Vasters (8) published a rather comprehensive paper on the use of Uspulun. They recommended it for the control of certain seed-borne and foliage diseases as well as for the control of aphis. Since the appearance of these papers, numerous reports have been published in Germany and other countries on the use of Uspulun and several other related and unrelated compounds. As is to be expected, some conflicting evidence has been presented but, on the whole, the reports indicate that the chlorphenol-mercury compounds are valuable. In 1920 Germisan (1), another organic mercury preparation (probably cyan-mercury-cresol), appeared on the market in Germany. The reports concerning Germisan have about the same status as those dealing with Uspulun, indicating that it merits further consideration in our program of investigation in this country. Various other German preparations have appeared on the market, but few of them seem to have merit (3). Among these few are preparations of copper-arsenic, ortho-nitro-phenol-mercury-sulphate and mercury-oxycyanide. Of the mercury materials prepared in this country, Semesan, Chlorophol, and Corona No. 620 have proved to be of value. The organic mercury compounds are more or less insoluble in water but are soluble in alkaline solutions. For this reason the commercial preparations contain alkalis.

During the past four years considerable interest has been shown in these organic mercury compounds in this country. Heald and Smith (4) found that Chlorophol would control bunt in wheat but they did not consider it as satisfactory as copper carbonate. Tisdale, Taylor, and Griffiths (11), in preliminary experiments, obtained excellent results with Chlorophol in the control of barley smuts. Since that time there has been published a number of reports on the use of the organic mercury materials as well as on other compounds and mixtures for the control of various seed-borne and soil-inhabiting fungi. Among these are both solutions and dusts.

The value of copper-carbonate dust in the control of bunt of wheat is of more recent discovery than the use of chlorphenol-mercury as a disinfectant. Darnell-Smith (2) of Australia reported the successful use of copper carbonate in 1917. It was first used in this country by Mackie and Briggs (6, 7) in 1920 for the control of bunt. Since its introduction it has become the most popular treatment for the control of bunt of wheat. The reasons for this popularity are its effectiveness, ease of application, elimination of soaking, lack of seed injury, and low cost. Copper carbonate has its limitations, however. It has not proved satisfactory for the control of the smuts of oats and barley, as will be shown by the results reported in this paper.

PRESENT INVESTIGATIONS

As previously stated, these investigations were undertaken with the chief object of testing new materials in the hope that something more satisfactory than the old standard treatments might be discovered. These materials were tested for the control of bunt of wheat and smuts of oats and barley. These investigations covered a period of four years, beginning in the spring of 1921, when hull-less oats were treated with Chlorophol, and extending through the crop season of 1924. For all of these experiments naturally infested seed was obtained when it could possibly be found and, in all cases except a few uninoculated untreated controls, the seed was thoroughly inoculated with viable smut spores before treating, whether it was naturally infested or not. The barley seed was inoculated with the spores of covered smut only. The loose smut came from natural infestation. In the fall of 1923 the oat and barley seed was run through a scarifying machine with the hope of rendering the inoculation more effective, as the removal of the hulls of barley had previously been found to render the seedlings more susceptible to infection (12).

In the fall of 1921 seed of Purplestraw wheat, Winter Turf oat, and Tennessee Winter and Han River barleys was treated with Chlorophol, copper carbonate, and some of the old standard treatments, and sown in fortieth-acre plats on Arlington Farm, Virginia. Uniform machine-threshed

seed of pure varieties grown on Arlington Farm the previous year was used for these experiments. In order to obtain accurate germination records on all treated seeds, two packets of 500 seeds each were counted out from each of the lots of seed, both treated and untreated, which were sown in the fortieth-acre plats. These counted seeds were sown in rod rows, 500 seeds to two rod rows, in soil as nearly comparable with the soil in the fortieth-acre plats as could be had. The rod-row sowings were duplicated with the second packet of counted seeds in each case. After their emergence the seedlings were counted and the percentages of emergence calculated from these figures. The emergence records from these duplicate plats of 500 seeds each should give a fair idea of the relative effects of these materials on the seed.

The smut records were obtained from the fortieth-acre plats by counting a given number of heads at regularly spaced intervals throughout the plats and recording the number of smutted heads. In cases where the percentages were low, less than one per cent, the smutted heads in the entire plat were counted. In the case of oats sown in the spring, the seed was counted and sown in rod rows. No fortieth-acre plats were sown and no attempt was made to obtain yield data. Only emergence counts and smut records were taken.

ROD-ROW EXPERIMENTS

As it was found to be impossible to run all of the tests in fortieth-acre plats, the materials were given a preliminary test in rod-row sowings. In these preliminary tests these compounds generally were used in several strengths, as many German investigators had reported that the strengths of solution recommended by the producers were too weak. The treatments which gave good results in the rod-row tests were later employed in the experiments in fortieth-acre plats.

The first of the chlorphenol-mercury compounds tested was Chlorophol. The solution was prepared by dissolving the Chlorophol in warm water, 3 grams in each liter of solution to be used. The seed was soaked for one hour and spread to dry before sowing. This treatment was applied to hull-less oats sown in rod rows in the spring of 1921, on Arlington Farm, Virginia, and at Manhattan, Kansas.[1] Both the loose and covered smuts were satisfactorily controlled with Chlorophol and there were no injurious effects on germination and plant growth, while formaldehyde (1:320, 10 min. soak) caused severe seed injury. A repetition of this experiment in 1922 was not so successful, due, evidently, to reinfestation of the seed.

[1] The writers are indebted to Mr. C. O. Johnston for sowing the seed and taking the notes at Manhattan.

TABLE 1.—*Effects of certain organic mercury compounds on the rate of emergence of Winter Turf oat seedlings from seed inoculated with Ustilago avenae, treated on January 11, 1922, and sown in soil on greenhouse benches at Arlington Farm, Rosslyn, Virginia, on the following day*

Treatment			Total number of seedlings emerged, on successive dates, from 400 seeds sown							Total emergence
			January					February		
Material	Strength of solution	Duration of soak	20	21	23	24	26	2	10	
	Pct.	Hours								Pct.
Dupont S.D. No. 12, salt	.1	1	154	246	320	335	356	384	386	96.50
Dupont S.D. No. 12, salt	.3	1	114	192	262	285	284	351	377	94.25
Chlorophol	.1	1	200	302	354	368	373	380	383	95.75
Chlorophol	.3	1	143	250	344	361	371	386	377	94.25
Untreated, inoculated			202	293	358	362	368	375	372	93.00
Untreated, uninoculated			155	255	342	345	361	371	369	92.25
Uspulun	.1	1	192	287	350	359	371	373	375	93.75
Uspulun	.3	1	114	240	331	348	365	377	377	94.25
Dupont S.D. No. 12, solution, 3–400			12	54	145	156	173	271	341	85.25
Dupont S.D. No. 12, solution, 1–400			134	222	293	309	326	368	373	93.25
Chlorophol	.3	1	254[a]	323	363	364	367	380	378	94.50
Dupont S.D. No. 12, dusted			35	65	137	146	151	250	271	67.75

[a] Treated November 25, 1921, and dried; sown January 12, 1922.

In the fall of 1921 seed of Winter Turf oat and Han River and Tennessee Winter barleys were treated with Chlorophol, copper carbonate and some of the standard treatments, and sown in rod rows (for emergence records) and in fortieth-acre plats to obtain smut control and yield data. In the fortieth-acre plats the seedlings grown from the Chlorophol-treated seed were much more vigorous than those from untreated seed or from seed treated with formaldehyde. The plats with seedlings from Chlorophol-treated seed could be distinguished easily by persons knowing nothing of the treatments. This led to a consideration of the possibility that there might be stimulation, as the German investigators had claimed. There certainly was a striking and easily measurable difference in the development of the seedlings. The question arose as to whether this was due to earlier germination of the seed or to a more rapid growth of the seedlings, or possibly to both. It seemed entirely possible that the seed coat was rendered more permeable and that this might have hastened germination by aiding the process of oxidation. It also seemed probable that, through having been effectively disinfected, the seed was freed from saprophytic as well as parasitic organisms and the seedling enabled to develop a clean and more efficient root system, and consequently more vigorous growth.

In a preliminary experiment in the greenhouse in the winter of 1921, it was found that both Chlorophol and Uspulun had a beneficial effect on the germination of Winter Turf oat and Purplestraw wheat from machine-threshed seed grown the previous season on Arlington Farm. In each case emergence was increased, the increases ranging from 4 per cent to 7.5 per cent. The seedlings also were more vigorous. In 1922 an effort was made to determine the rate of emergence by treating seed of Winter Turf oat with the mercury compounds then available and sowing them in carefully prepared soil in greenhouse benches. These materials were prepared when used in solution by weighing out 1, 2, or 3 grams, according to strength desired, for each liter of solution to be used, and then dissolving in the desired quantity of warm water. The seed was placed in the solution in cheesecloth bags and soaked for the desired time, and then spread to dry before sowing. Where dusts were used they were applied to the measured grain at the proper rate, generally 2 to 3 ounces per bushel, and the grain was then shaken in a jar or closed can or box until each kernel was thoroughly covered with dust. These experiments were conducted in January and February, 1922. In both experiments the seed was treated one day previous to sowing.

The results of these experiments, as given in tables 1 and 2, show that some of these materials had a tendency to hasten germination slightly. This is particularly true of Chlorophol in table 1, line 11, where the seed

TABLE 2.—*Effects of certain organic mercury compounds on the rate of emergence of Winter Turf oat seedlings from seed inoculated with Ustilago avenae, treated on January 25, 1922, and sown in soil on greenhouse benches at Arlington Farm, Rosslyn, Virginia, the following day*

Treatment			Total number of seedlings emerged, on successive dates, from 400 seeds sown						Total emergence
Material	Strength of solution	Duration of soak	February						
			2	4	6	9	14	18	
	Pct.	Hours							Pct.
Corona No. 10	.2	1	7	132	301	375	385	387	96.75
Corona No. 10	.1	1	31	233	350	383	384	387	96.75
Dupont S.D. No.12, dry	.1	1	8	208	311	344	359	366	91.50
Corona No. 620	.2	1	6	184	308	360	367	374	93.50
Corona No. 620	.1	1	0	265	352	381	383	383	95.75
Corona No. 30	.2	1	8	241	348	368	379	379	94.75
Corona No. 30	.1	1	11	245	364	387	388	386	96.50
Untreated, inoc.			4	153	328	367	371	369	92.25
Untreated, uninoc.			12	183	322	370	375	373	93.25
Corona No. 640–S, dusted			1	36	242	358	378	378	94.50
Corona No. 50	.2	1	1	19	53	183	248	271	67.75
Corona No. 50	.1	1	2	24	93	253	292	319	79.75
Chlorophol	.3	1	21	258	330	374	385	385	96.25
Uspulun	.3	1	1	209	332	375	384	385	96.25

was treated with a .3 per cent solution on November 11, 1921, and sown January 12, 1922, after it was thoroughly dry. These seedlings were noticeably further advanced when the first emergence counts were made than were those from untreated seed, although the final records for emergence show the percentages to be but little different. In table 2, the records of February 2 show emergence to be slightly better from seed treated with Corona No. 10 (.1 per cent, 1 hour soak) and Chlorophol (.3 per cent, 1 hour soak), while all other materials used seemed to retard emergence. On February 4, most of these treatments showed better results than did the untreated seed. In both tables 1 and 2, seed treated with these materials, with the exception of Dupont S.D. No. 12 (solution 1–400), Dupont S.D. No. 12 (dusted), and Corona No. 50, finally emerged about as well as or better than did the seedlings from untreated seed.

In further preliminary field tests on spring-sown Kherson oat in 1922 and 1923, a number of compounds were used in different strengths and the seed was soaked for different periods of time. All of these materials were not used in both years because, as previously stated, some of them were available in only one year and others were eliminated because proving unsatisfactory after the first year's test. Time and space were too limited to continue with materials of no promise. An important factor which renders results with such materials uncertain is the question as to whether the chemical composition of any given compound has remained the same. Some samples of certain of them have contained dyes, while other samples of the same compound have not. There also has appeared to be a difference in the rate at which different samples under the same name will dissolve in water at approximately the same temperature. However, the results have been fairly consistent with some of these compounds.

After the first year's experiments, previously described, warm water was not used in dissolving the organic mercury compounds. They were weighed out and placed in the desired quantities of tap water and dissolved by thorough stirring. Some few of the materials were furnished by the manufacturers with rather complicated directions for their preparation and application. Since none of these have proved satisfactory it will not be necessary to give these directions. After treating the seed it was thoroughly dried and sown as soon after drying as possible. The results of the tests with spring-sown Kherson oat are given in table 3. Very few of the materials listed in this table are being manufactured. However, the table will give some idea of the number of materials tested and the reasons for eliminating many of them.

The data in table 3 show that several of these materials gave fairly good results in the control of oat smuts and some of them had a decidedly

TABLE 3.—*Effects of various seed disinfectants on the emergence and percentages of smut in spring sown Kherson oat after the seed was inoculated with spores of loose and covered smuts, and sown on Arlington Farm, Virginia, in 1922 and 1923*

Treatment			Average percentages					
Material	Strength of solution	Duration of soak	1922		1923		Two years	
			Germination	Smut	Germination	Smut	Germination	Smut
	Pct.	Hours						
Untreated, inoc.	—	—	60.0	10.60	85.8	3.75	72.90	7.17
Chlorophol	.3	1	72.2	1.55	91.7	0.0	81.95	0.77
Chlorophol	.3	½	71.7	0.15	92.0	0.0	81.85	0.07
Chlorophol	.3	¼	69.6	0.15	.....	.....	.....	.....
Chlorophol	.2	1	72.8	0.0	90.2	0.0	81.50	0.0
Chlorophol	.2	½	72.4	0.40	90.7	0.15	81.55	0.27
Chlorophol	.2	¼	67.9	0.54	.....	.....	.....	.....
Chlorophol	.1	1	68.7	0.14	.....	.....	.....	.....
Chlorophol	.1	½	67.1	0.27	.....	.....	.....	.....
Chlorophol	.1	¼	64.9	0.41	.....	.....	.....	.....
Chlorophol	.05	1	71.2	0.25	.....	.....	.....	.....
Chlorophol	.05	½	71.2	2.46	.....	.....	.....	.....
Chlorophol	.05	¼	60.8	1.20	.....	.....	.....	.....
Untreated, uninoc.	—	—	63.0	1.34	.....	.....	.....	.....
Chlorophol	.06 (spray)	—	64.0	7.56	.....	.....	.....	.....
Corona No. 10	.2	1	69.3	1.71	.....	.....	.....	.....
Corona No. 10	.2	½	64.8	1.53	.....	.....	.....	.....
Corona No. 10	.2	¼	63.7	0.83	.....	.....	.....	.....
Corona No. 10	.1	1	68.9	2.15	.....	.....	.....	.....
Corona No. 10	.1	½	69.4	1.73	.....	.....	.....	.....
Corona No. 10	.1	¼	68.0	4.38	.....	.....	.....	.....
Corona No. 10	.05	1	65.0	1.50	.....	.....	.....	.....
Corona No. 10	.05	½	63.3	3.11	.....	.....	.....	.....
Corona No. 10	.05	¼	67.1	0.15	.....	.....	.....	.....

TABLE 3.—(*Continued*)

Treatment			Average percentages					
Material	Strength of solution	Duration of soak	1922		1923		Two years	
			Germination	Smut	Germination	Smut	Germination	Smut
	Pct.	Hours						
Corona No. 10	.6 (spray)		63.5	5.37				
Untreated, uninoc.			51.6	0.35				
Untreated, inoc.			56.7	10.07	87.9	2.7		
Semesan	.3	½			92.7	0.4		
Semesan	.2	1			92.5	1.5		
Semesan	.2	½			92.9	1.25		
Semesan	.1	1			92.1	1.55		
Germisan	.3	1			93.0	0.0		
Germisan	.3	½			90.3	0.0		
Germisan	.2	1			94.0	0.0		
Germisan	.2	½			92.9	0.05		
Germisan	.1	1			93.4	0.1		
Germisan	.1	½			94.6	0.05		
Tillantin B	.2	1			86.8	0.3		
Tillantin B	.2	½			88.5	0.45		
Tillantin C	.2	1			90.7	0.05		
Tillantin C	.2	½			87.7	0.2		
Untreated, inoc.					84.7	4.35		
Corona No. 620	.2	1	62.9	0.30	88.3	0.05	75.60	0.01
Corona No. 620	.2	½	57.7	0.0	85.5	1.02	71.60	0.51
Corona No. 620	.2	¼	64.1	0.0	85.9	1.05	75.00	0.57
Corona No. 620	.1	1	73.2	0.0	86.1	0.77	79.65	0.38
Corona No. 620	.1	½	76.1	0.64	84.8	1.85	80.45	1.24
Corona No. 620	.1	¼	76.6	0.39	89.3	1.25	82.95	0.82
Corona No. 620	.05	1	71.2	0.13	89.9	1.65	80.55	0.89

TABLE 3.—(*Continued*)

Treatment			Average percentages					
Material	Strength of solution	Duration of soak	1922		1923		Two years	
			Germination	Smut	Germination	Smut	Germination	Smut
	Pct.	Hours						
Corona No. 620	.05	½	70.6	0.41	90.5	0.93	80.55	0.67
Corona No. 620	.05	¼	77.5	0.39	89.3	1.17	83.40	0.78
Corona No. 620	.6 (spray)	.....	72.0	1.66	.....	.....	.....	.....
Corona No. 620, impure	.2	1	72.7	0.0	.....	.....	.....	.....
Corona No. 620, impure	.2	½	67.8	0.87	.....	.....	.....	.....
Corona No. 620, impure	.2	¼	73.5	0.0	.....	.....	.....	.....
Uspulun	.3	1	72.5	0.0	.....	.....	.....	.....
Uspulun	.3	½	74.8	0.0	.....	.....	.....	.....
Uspulun	.3	¼	70.6	0.94	.....	.....	.....	.....
Uspulun	.1	1	70.4	0.15	.....	.....	.....	.....
Uspulun	.1	½	75.9	1.05	.....	.....	.....	.....
Uspulun	.1	¼	72.6	1.40	.....	.....	.....	.....
Untreated, uninoc.	.....	.....	63.5	0.15	.....	.....	.....	.....
Untreated, inoc.	.....	.....	57.3	5.59	.....	.....	.....	.....
Formaldehyde, 1: 320	.....	1/6	56.0	0.0	73.7	0.18	64.85	0.09
Formaldehyde, 1: 1 (spray)	.....	.....	21.8	0.0	.....	.....	.....	.....
Formaldehyde, 1: 320	.....	1/6 wash in water	.....	.....	76.3	0.98	.....	.....
Formaldehyde, 1: 320	.....	1/6 wash-lime water	.....	.....	83.1	0.31	.....	.....
Formaldehyde, 1: 320	.....	½	.....	.....	30.0	0.0	.....	.....
Formaldehyde, 1: 320	.....	½ wash in water	.....	.....	75.4	trace	.....	.....
Formaldehyde, 1: 320	.....	½ wash-lime water	.....	.....	78.1	0.0	.....	.....

TABLE 3.—(*Continued*)

Treatment			Average percentages					
Material	Strength of solution	Duration of soak	1922		1923		Two years	
			Germination	Smut	Germination	Smut	Germination	Smut
	Pct.	Hours						
Formaldehyde, 1:320	....	1	.....	.....	27.0	0.0	.....	.....
Formaldehyde, 1:320	....	1 wash in water	.....	.....	66.0	0.0	.....	.....
Formaldehyde, 1:320	.....	1 wash-lime water	.....	.....	72.9	0.18	.....	.....
Fertilisa, soak	.....	5	59.8	0.0	.....	.....	.....	.....
Fertilisa, soak	....	3	61.5	0.08	.....	.....	.....	.....
Kalimat	.3	½	.....	.....	78.2	0.0	.....	.....
Pythal	.75	½	.....	.....	91.4	0.43	.....	.....
Untreated, inoc.	....	....	.....	.....	86.5	5.7	.....	.....
Dupont S.D. No. 12, powder	.1	1	57.1	0.71	.....	.....	.....	.....
Dupont S.D. No. 12, powder	.1	½	55.9	0.52	.....	.....	.....	.....
Dupont S.D. No. 12, liquid, 1:400	....	1	68.1	0.56	.....	.....	.....	.....
Dupont S.D. No. 12, liquid, 1:400	....	½	57.8	1.96	.....	.....	.....	.....
Dupont S.D. No. 1	.3	1	65.5	0.33	.....	.....	.....	.....
Dupont S.D. No. 1	.1	1	70.4	0.41	.....	.....	.....	.....
Dupont S.D. No. 2	.3	1	65.4	0.45	.....	.....	.....	.....
Dupont S.D. No. 2	.1	1	63.1	1.40	.....	.....	.....	.....
Untreated, uninoc.	.....	....	51.0	0.75	.....	.....	.....	.....
Untreated, inoc.	....	....	52.8	15.77	81.6	5.50	67.20	10.63
Corona No. 40F, coarse powder	....	dust	63.1	1.73	.....	.....	.....	.....
Corona No. 40F, with inert	....	dust	58.1	3.23	.....	.....	.....	.....
Corona No. 640–8	....	dust	54.0	1.20	86.9	1.5	70.45	1.35
Seed-O-San, pink dust	....	....	53.4	7.09	88.5	2.75	70.95	4.92
Seed-O-San, white dust	....	....	.....	.....	83.5	1.5	.....	.....

TABLE 3.—(*Continued*)

Treatment			Average percentages					
Material	Strength of solution	Duration of soak	1922		1923		Two years	
			Germination	Smut	Germination	Smut	Germination	Smut
	Pct.	Hours						
Copper Carbonate C.P., 2 oz. per bu.	....	dust	47.2	0.57	82.3	1.45	64.75	1.01
Corona Coppercarb	....	dust	54.4	1.39	.....	.....	.....	.....
Coppercarb, 2 parts, to Dupont S.D. No. 2, 1 part	....	dust	56.8	1.76	.....	.....	.....	.....
Dupont Dust Disinfectant, No. 2	....	dust	.....	.....	83.8	1.65	.....	.....
Dupont Dust Disinfectant, No. 6	....	dust	.....	.....	86.9	1.40	.....	.....
Untreated, uninoc.	....	....	55.5	0.55	.....	.....	.....	.....
Untreated, inoc.	....	....	55.2	10.48	81.6	5.5	68.4	7.99

beneficial effect on germination of the seed. These differences easily could be seen in the field a few days after the seedlings had emerged, and often were maintained throughout the life of the plants, as is indicated by the yields from some of the fortieth-acre plats (Table 6). This difference could not always be seen, however. In the Winter Turf oat in 1923 there was practically no discernible difference in the plants at any stage of development. All of the plats were so poor, however, that no attempt was made to obtain yield data.

In a further test of some of these treatments on Cusado barley and Winter Turf oat sown in the fall of 1922 on Arlington Farm, germination records were obtained from duplicate sowings of 500 seeds each. Smut records, the number of smutted heads per rod row, were obtained on the barley the following spring, but no smut records were obtained on the oats because very little smut developed, even in the plants from untreated seed. In the fortieth-acre plats, with the same treatments, none of these compounds completely controlled either of the two oat smuts. There was only a trace of smut in the check plats, however. None of the oats from treated seed was entirely smut-free. The results of these rod-row tests of oats and barley are shown in table 4.

The data in table 4 show that some of these materials were more effective than formaldehyde (1:320, 10 min.) for the control of both smuts of barley, and in many cases germination both of oats and barley was improved rather than injured, in contrast to results from using formaldehyde.

EXPERIMENTS IN FORTIETH-ACRE PLATS

Only the treatments which in rod-row experiments showed no harmful effects to germination and at the same time controlled the smuts were used for treating seed for the fortieth-acre plats. The preparation and application of the treatments were the same as described under rod-row experiments. Seedling-emergence records and subsequent smut and yield records were obtained from these plats.

Bunt of wheat. Comparatively few of these liquid treatments were used in these experiments for the control of bunt for the reason that copper carbonate had proved so satisfactory. As copper carbonate is a dust and so easy to apply, it hardly seemed worth while to use solutions in the hope of finding something so much better as to replace the dust. After the first year some of the liquids were discarded. In the third year only one solution, copper-sulphate-lime, was used. Such dusts as were available and seemed to be promising were used in these tests. Table 5 gives the germination and bunt percentages and the acre yields in bushels of Purplestraw wheat treated with these various compounds. The 1922 and 1923 figures

TABLE 4.—*Effects of various seed disinfectants on the germination of Cusado barley and Winter Turf oat, and on the control of the smuts in barley. Seed sown on October 4 and 5, 1922, Arlington Farm, Virginia.*

Treatment			Cusado barley									Winter Turf oat		
			Plat 1			Plat 2			Average			Germination		
				Heads in rod row			Heads in rod row			Heads in rod row				
Material	Strength of solution	Duration of soak	Germination	Covered smut	Loose smut	Germination	Covered smut	Loose smut	Germination	Covered smut	Loose smut	Plat 1	Plat 2	Average
	Pct.	Hour	Pct.			Pct.			Pct.			Pct.	Pct.	Pct.
Untreated, inoc.			74.8	55	7				74.80	55.0	7			
Uspulun	.3	1	76.6	0	0	89.0	0	0	82.80	0	0	73.8	76.0	74.90
Uspulun	.3	½	61.2	0	0	84.0	1	0	72.60	.50	0	76.0	77.0	76.50
Uspulun	.15	1	79.2	0	0	83.0	4	0	81.10	2	0	73.6	78.0	75.80
Germisan	.3	1	82.4	0	0	83.0	0	0	82.70	0	0	75.4	73.0	74.20
Germisan	.3	½	80.8	2	0	86.0	2	0	83.40	2	0	82.0	81.0	81.50
Germisan	.15	1	82.8	8	0	85.0	8	1	83.90	8	.50	83.6	85.0	84.30
Untreated, inoc.			77.4	47	22	81.0	62	1	79.20	54.50	11.50	83.2	90.0	86.60
Chlorophol	.3	1	79.8	0	0	83.0	0	0	81.40	0	0	84.4	76.0	80.20
Chlorophol	.3	½	78.6	0	0	87.0	0	0	82.80	0	0	85.6	86.0	85.80
Chlorophol	.15	1	87.6	0	0	79.0	0	0	83.30	0	0	82.6	87.0	84.80
Semesan	.3	1	86.6	0	0	76.0	0	0	81.30	0	0	83.4	83.0	83.20
Semesan	.3	¼	84.8	1	0	73.0	5	1	78.90	3.00	.50	74.6	82.0	78.30
Semesan	.2	1	82.0	41	3	77.0	26	0	79.50	33.50	1.50	78.2	78.0	78.10
Semesan	.1	1	83.4	30	16	75.0	15	10	79.20	22.50	13.00	77.8	79.0	78.40
Untreated, inoc.				60	5	79.7	25	5	79.70	42.50	5.00	78.4	80.0	79.20

TABLE 4.—*Continued*

Treatment			Cusado barley									Winter Turf oat		
			Plat 1			Plat 2			Average			Germination		
Material	Strength of solution	Duration of soak	Germination	Heads in rod row		Germination	Heads in rod row		Germination	Heads in rod row		Plat 1	Plat 2	Average
				Covered smut	Loose smut		Covered smut	Loose smut		Covered smut	Loose smut			
	Pet.	Hour	Pet.			Pet.			Pet.			Pet.	Pet.	Pet.
Corona No. 620	.2	1	76.4	3	0	70.0	0	0	73.20	1.50	0	76.0	74.0	75.00
Corona No. 620	.2	½	73.2	0	0	68.0	0	0	70.60	0	0	74.8	78.0	76.40
Corona No. 620	.2	¼	80.4	0	0	76.0	0	0	78.20	0	0	73.6	70.0	71.80
Corona No. 620	.1	1	88.4	1	0	70.0	1	1	79.20	1	.50	75.4	75.0	75.20
Corona No. 620	.1	¼	88.0	0	0	72.0	0	1	80.00	0	.50	76.4	81.0	78.70
Corona No. 620	.05	1	89.8	0	0	81.0	0	0	85.40	0	0	66.4	81.0	73.70
Copper carbonate		dust	93.4	28	13	80.0	33	1	86.70	30.50	7.00	65.0	82.0	73.50
Dupont S.D. No. 12		dust	86.4	9	4	83.0	7	0	84.70	8.00	2.00	75.6	87.0	81.30
Formaldehyde, 1:320		⅙	76.2	4	0	69.0	4	0	72.60	4.00	0	73.2	72.0	72.60
Untreated, inoc.				70	4		14	0		42.00	2.00	84.0	79.0	81.50
Jacobsohn's No. 1	.3	1	85.0	1	0	83.0	0	0	84.00	.50	0	80.0	74.0	77.00
Jacobsohn's No. 1	.2	1	87.4	0	0	78.0	2	0	82.70	1.00	0	83.0	79.0	81.00
Jacobsohn's No. 2	.3	1	82.8	0	0	84.0	0	0	83.40	0	0	81.0		81.00
Jacobsohn's No. 2	.2	1	90.4	0	4	73.0	6	0	81.70	3.00	2.00	81.0	85.0	83.00
Jacobsohn's No. 5	.3	1	75.8	0	0	74.0	1	0	74.90	.50	0	85.0	76.0	80.50
Jacobsohn's No. 5	.2	1	85.8	0	0	81.0	2	0	83.40	1.00	0	84.0	81.0	82.50
Corona No. 10	.2	1	88.0	0	0	67.0	0	0	77.50	0	0	92.0	80.0	86.00
Dupont S.D. No. 11–1	.25	1	90.4	0	0	76.0	0	0	83.20	0	0	85.0	75.0	80.00
Untreated, inoc.				20	0		35	0		27.50		86.0	76.0	81.00

are averages of duplicate plats, while those for 1924 are averages of three replications. Some of these materials were not used in all three years, because (1) they were not available; (2) others were discarded due to lack of effectiveness; and (3) still others were liquids which were not considered so satisfactory as dusts for the control of bunt and therefore were discarded. A larger number of the new compounds were used in rod-row tests, but no bunt occurred even in the controls, so these data were not tabulated.

All factors considered, copper carbonate proved to be the most satisfactory of all the treatments listed in table 5, although it was hardly as effective as copper-sulphate-lime in preventing bunt. In the final averages, Chlorophol seems to have been better both from the standpoint of bunt control and yield. The difference in average yield is due to the fact that Chlorophol was not used in the 1924 crop when the yields were low. Copper carbonate proved better than Chlorophol in both years when the latter was used. Coppercarb, which has a much lower percentage of metallic copper than is contained in the pure copper carbonate, produced excellent results in 1924.

Oat Smuts. Only a few materials were used on oats sown in fortieth-acre plats in 1921 and 1923. In the fall of 1921 only a few were available, and, at the time of fall sowing in 1923, many had been discarded. A larger number of compounds were used on seed sown in 1922, but unfortunately very little smut developed in the controls, so the experiments were worthless from the standpoint of determining smut control. At the same time, the stands were so irregular, because of winter killing and non-uniform soil, that the yield records at harvest time in 1923 were worthless. Again, in 1924, little smut developed, even though the seed was scarified before inoculating, and therefore only the yield records are given. During these two years, however, most of the plats produced a trace of smut, but not so much as occurred in the control plats. Table 6 gives the records taken from duplicate or triplicate plats for each treatment. In the fall of 1921 the seed was divided into two parts; one part was inoculated with loose smut, and the other with covered smut. Duplicate plats from seed of each treatment of each of these two seed lots were sown. In the fall of 1923 the two smuts were mixed and all the seed was inoculated with the mixture, and triplicate plats from seed of each treatment were sown.

The results in table 6 show that Chlorophol had a beneficial effect on germination and yield and at the same time controlled both smuts in 1922, the only year when smut appeared. Copper carbonate dust was beneficial to germination and yield but failed to give satisfactory smut control. Some others of the mercury materials have shown good effects on germination and

TABLE 5.—*Effects of certain disinfectants on emergence, bunt infection, and yields of Purplestraw wheat (C.I. 1915) grown from treated seed on fortieth-acre plats on Arlington Farm, Virginia, in the three years 1922–1924, inclusive*

Treatment			Average emergence, bunt infection, and yield											
			1922			1923			1924			2 or 3 year[b]		
			Per cent			Per cent			Per cent			Per cent		
Material	Strength of application	Duration of soak	emergence	bunt	Bushel per acre	emergence	bunt	Bushel per acre	emergence	bunt	Bushel per acre	emergence	bunt	Bushel per acre
	Pet.	Hour												
Untreated, inoc.			76.25	52.17	21.8	57.0	0.89	29.9	76.33	78.6	5.4	69.86	43.89	19.0
Copper carbonate (C.P.)	2 oz. bu.	dust	77.75	0.80	33.0	67.0	0.0	36.4	77.0	0.0	18.4	73.92	.27	29.3
Chlorophol	.3	1	80.00	0.38	31.1	65.0	0.0	34.5				72.50	.19	32.8
Formaldehyde 1:320		1/6	76.75	0.37	30.7									
Copper sulphate	1–10	dip	75.5	0.03	32.1	58.0	0.0	35.6	81.00	trace	15.8	71.50	.01	27.8
Lime	1–10	dip				65.0	0.0	32.9	77.00	22.0	15.6	71.00	11.00	24.2
Seed-O-San	1 oz. bu.	dust				60.5	0.0	33.6						
Corona No. 620	.1	1				72.0	0.0	36.3	82.0	2.0	20.6	77.00	1.00	28.4
Corona No. 408	2 oz. bu.	dust							78.0	0.0	20.0			
Coppercarb	2 oz. bu.	dust							82.0	trace	18.7			
Semesan	2 oz. bu.	dust							74.0	2.0	15.3			
Dupont D.D. No. 8	2 oz. bu.	dust							80.0	1.0	16.0			
Dupont D.D. No. 9	2 oz. bu.	dust												

[b] Two- and three-year averages should not be compared. They are included for convenience in reading the results.

TABLE 6.—*Annual and average effects of various treatments on emergence, smut infection, and yields of Winter Turf oat grown from inoculated, treated seed sown on Arlington Farm, Virginia, on fortieth-acre plats in the fall of 1921 and 1923*

Treatment			Crop of 1922 inoculated with						Crop of 1924 inoculated with both smuts		2-year average acre yield
			Loose smut			Covered smut					
Material	Strength of solution	Duration of soak	Emergence	Infection	Acre yield	Emergence	Infection	Acre yield	Emergence	Acre yield	
	Pct.	Hours	Pct.	Pct.	Bu.	Pct.	Pct.	Bu.	Pct.	Bu.	Bu.
Untreated, inoc.			83.00	2.55	45.7	83.25	8.40	39.3	65.0	37.3	39.9
Chlorophol	.3	1	89.75	0.03	54.0	89.75	0.02	42.4	72.0	42.5	45.3
Formaldehyde 1:320		1/6	86.00	0.15	48.6	82.5	0.04	44.1	58.0	34.6	40.5
Formaldehyde 1:320		1/2									
		wash in water							64.0	30.6	
Copper carbonate		dust	88.75	0.27	50.2	82.5	1.45	37.8			
Semesan	.3	1							66.0	40.4	
Corona No. 620	.2	1							60.0	42.0	
Furfural (C.P.)	.5	1							32.0	16.5	
Furfural (Com.)	.5	1							35.0	22.1	

yield, but unfortunately the results were valueless in 1923 when the largest number of them were used. Furfural proved very injurious to the seed in the strength of solution used. This strength, even though injurious to barley seed, failed to control the barley smuts. (See table 7 and plate 3–B.) No smut occurred in the oats, so that no record was obtained of its effectiveness in the control of oat smuts.

Barley Smuts. Three years' records are available on the control of barley smuts. The data for the first year, however, have been published in PHYTOPATHOLOGY (11). In the 1924 crop the percentages of smut infection were rather high in the controls, and the smut control records of the treatments therefore are rather significant. No yield data are available, however, due to winter-killing and poor development of the plants in spots throughout the plats. The seed for the 1924 crop was run through a scarifying machine before inoculating in order to break the hulls with the hope that higher percentages of smut might occur, such as were obtained by Tisdale (12) when the hulls were carefully removed with a scalpel. Rather high percentages of smut infection were obtained. This may have been due to the scarifying or to natural infestation, as heavily infested seed was used. Tennessee Winter barley was used for these experiments. The results of these tests are given in table 7.

The previously published records for 1922 are not given in this table. Chlorophol was the only organic mercury compound used in these 1922 experiments. Seed of both Han River and Tennessee Winter barleys was treated. The results (11) show that, from the standpoint both of smut control and of yield, Chlorophol was superior to formaldehyde, hot water, and copper carbonate. Copper carbonate failed to control the smuts of barley.

The figures in table 7 show that several of the organic mercury compounds were superior to formaldehyde from the standpoint of seed germination, smut control (Plates 2, 3, and 4), and yield of plants from treated seed. The highest yields were obtained with Semesan .3 per cent (1-hour soak), Chlorophol (Plate 4–A) .3 per cent (1-hour soak), and Corona No. 620, a .2 per cent solution (¼-hour soak). From the results obtained with a .2 per cent Semesan solution, the indications are that a solution weaker than .3 per cent could not be used successfully. Corona No. 620, however, apparently can be used in very weak solutions with good results (Plate 2–A). This would be of considerable advantage in the use of such expensive materials as the mercury compounds. Formaldehyde followed by a water bath was not as effective as formaldehyde alone (Plate 2–B). The dusts failed to control smuts of barley (Plate 3–A). Furfural did not control smut and injured the seed (Plate 3–B). In fact, the percentages of smut were higher than in the controls (Plate 4–B).

TABLE 7.—*Effects of seed treatments on emergence, smut control, and yield of Tennessee Winter barley sown in duplicate for 1923 and triplicate for 1924 in fortieth-acre plots on Arlington Farm, Rosslyn, Virginia. Crops of 1923 and 1924*

Material	Treatment		Average emergence, infection, and yield									
			Crop of 1923				Crop of 1924				Two-year	
	Strength of solution	Duration of soak	Emergence	Covered smut	Loose smut	Per acre	Emergence	Covered smut	Loose smut	Emergence	Covered smut	Loose smut
	Pct.	Hours	Pct.	Pct.	Pct.	Bu.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Untreated, inoc.			77.9	14.2	5.1	33.8	76.0	25.31	4.19	76.95	19.75	4.64
Dupont Dust Disinfectant No. 12		dust	84.7	7.6	1.7	33.6						
Chlorophol	.3	1	81.4	trace	trace	45.5	69.0	trace	trace	75.20	trace	trace
Uspulun	.3	1	82.8	trace	trace	38.3				82.80	trace	trace
Germisan	.3	1	82.7	trace	trace	44.7				82.70	trace	trace
Semesan	.3	1	81.3	trace	trace	47.6	78.0	trace	0	79.65	trace	0
Semesan	.2	1	79.5	18.5	2.2	41.9				79.50	18.50	2.20
Formaldehyde 1:320		1/6	72.6	17.1	0.3	35.4	70.0	4.93	trace	71.30	11.01	0.15
Formaldehyde 1:320		1/2 wash in water					74.0	23.81	1.19			
Copper carbonate		dust	86.7	15.8	3.1	33.1						
Untreated, inoc.			77.9	21.4	2.2	39.5	76.0	27.62	2.62	76.95	24.51	2.41
Corona No. 620	.2	1	73.2	trace	trace	41.5	76.0	trace	trace	74.60	trace	trace
Corona No. 620	.2	1/2	70.6	trace	trace	39.7						
Corona No. 620	.2	1/4	78.2	trace	trace	45.2						
Corona No. 620	.1	1	79.2	trace	trace	43.3	76.0	4.0	trace	77.60	2.0	trace
Corona No. 620	.05	1	85.4	trace	trace	43.1						
Furfural (C. P.)	.5	1					not taken	31.2	4.27			
Furfural (Com.)	.5	1					68.0	30.0	3.73			
Corona No. 408		dust					80.0	11.33	4.87			
Untreated, inoc.			77.9	14.5	2.25	40.3	76.0	26.80	2.80	76.95	20.65	2.52

In the fall of 1923 several varieties of barley were sown in fortieth-acre plats after treating with Semesan, one of the chlorphenol-mercury-sulphate compounds. Adjacent to each treated plat was one sown with comparable untreated seed of the same variety. The striking results of these treatments, based upon the averages of duplicate plats, are given in table 8. Semesan was used for these experiments because a supply was on hand at the time. Other organic mercury compounds might have been used with good results.

TABLE 8.—*Effects of Semesan (.3 per cent solution, 1-hour soak) on the control of smut and the yields of winter barleys, grown in duplicate fortieth-acre plats on Arlington Farm, Rosslyn, Virginia, crop of 1924*

Plat No.	Variety	Treatment	Average infection and yield		
			Covered smut	Loose smut	Per acre
			Pet.	Pet.	Bu.
1 & 36	Wisconsin Winter (C.I. 2159)	Semesan	0	0	40.75
2 & 37	Wisconsin Winter (C.I. 2159)	Untreated	21.7	1.25	31.10
9 & 44	Orel (C.I. 351)	Semesan	0	0	43.10
10 & 45	Orel (C.I. 351)	Untreated	trace	trace	39.2
22 & 57	Tennessee Winter (Sel. 52)	Semesan	0	0	45.3
23 & 58	Tennessee Winter (Sel. 52)	Untreated	32.7	5.35	37.65

The data in table 8 show that Semesan was very effective in the control of the barley smuts in these varieties. The yields were much better from plats grown from treated seed. There was considerable improvement in the yield of Orel from treated seed even though there was only a trace of either smut in plants from untreated seed. No careful records were made of the occurrence of other diseases which might have been controlled. The plants from Semesan-treated seed outyielded the neighboring plants from untreated seed in all six instances. Barley seedlings from seed treated with Semesan and sown on Arlington Farm in the fall of 1924 also are showing the beneficial effects previously mentioned (Plate 1). The seed was taken from uniform lots of machine-threshed seed grown on Arlington Farm in the previous season.

DISCUSSION

In preliminary experiments a number of new seed disinfectants produced a beneficial effect on germination of the treated seed and at the same time gave promise of good smut control. Among these materials copper carbonate dust, as reported by other investigators, produced excellent control

of bunt. The stands of grain from treated seed and the yields also were improved. It failed, however, to satisfactorily control the smuts of oats and barley. Among the more promising of the mercury compounds used in these preliminary tests were Chlorophol, Corona No. 620, Germisan, Semesan, and Uspulun.

The more promising materials were used in experiments in fortieth-acre plats from which yield data were obtained. In these fortieth-acre experiments copper carbonate proved the most satisfactory material for the control of bunt in wheat. The germination of the seed was improved, bunt was satisfactorily controlled, and the yields were good as compared with those of other treatments. The copper carbonate treatment is less expensive than those with the mercury dusts now being prepared. Some of the liquid-mercury treatments gave excellent results in the control of bunt, but their use is not considered practicable in view of the highly satisfactory results obtained with the cheap and easily applied copper-carbonate dust. Only dusts which are either more effective or less expensive, or both, are likely to compete successfully with copper carbonate.

Copper carbonate, however, failed to cause entirely satisfactory control of oat smuts and reduced the smuts of barley only slightly. It showed beneficial effects on germination of these grains, but the lack of control of the smuts makes it undesirable. So far, none of the dust treatments has proved entirely satisfactory for the control of the smuts of oats and barley. For this reason the liquid treatments were used more extensively on the seed of these crops. The failure to obtain smut infection in the untreated plats of oats in two of the years leaves insufficient data to warrant any definite conclusions concerning the fungicidal value of these new materials in controlling smuts of fall-sown oats. The writers believe, however, that liquid treatments are necessary for best results, and that formaldehyde should be recommended until we have positive proof of the superiority of some other material.

In the control of barley smuts, several of the organic mercury compounds, including Chlorophol, Corona No. 620, Germisan, Semesan, and Uspulun have given excellent results. In the experiments herein described the results with these compounds undoubtedly are superior to those obtained with formaldehyde from the standpoint of seed germination, smut control, and yields of plants from treated seed. As has been previously reported, both smuts have been controlled satisfactorily. These materials, however, are more expensive than formaldehyde and also are poisonous. The additional expense, however, is more than compensated by the increased germination and yields. There also is a possibility of saving seed by sowing less of the treated seed. Care should be used with treated grain to prevent poisoning of animals.

According to Henning (5), and others, the active ingredients in the mercury compounds are absorbed rapidly by the seed and the solutions become weaker with use. This would render them less desirable. However, this could be overcome by adding a new supply of the material after each lot of seed is removed from the solution. The quantity to be added would have to be determined on the basis of strength desired and the volume of solution in question.

Formaldehyde, followed by a wash in clear water, as recommended by Henning, does not cause the seed injury often resulting from formaldehyde alone, but in the case of barley the control of smuts was not so satisfactory as was the control with formaldehyde alone.

Some of these new disinfectants have had a beneficial effect in most cases on the germination of machine-threshed seed taken from uniform seed lots of pure varieties. The yields have been improved in many cases. In some cases the increase in yield has been more than could be accounted for through smut control. In table 8 it will be noted that where only a trace of smut occurred in Orel barley, plants from seed treated with Semesan yielded better than plants from untreated seed. This difference, however, was not great. It is possible that it could have been caused by other organisms on the seed or in the soil which injured germination and subsequent development of seedlings from untreated seed.

Excluding the contamination from smut, the seed sown in these experiments probably was as good as or better than the average lot of seed sown by the farmer. When the percentages of germination were high, the improvement by treatment with these compounds was less pronounced. This would seem to indicate that if it were possible to eliminate all parasitic and probably certain saprophytic organisms, both on the seed and in the soil, which attack the germinating seed, little benefit would be derived by treating seed of high vitality. In other words, there is a question as to whether these treatments actually cause stimulation. Of course, elimination of the disease factors mentioned above is not possible in farm practice, but an approach to it through seed treatment is possible and worth while.

On the whole, copper carbonate dust caused the most satisfactory control of bunt in wheat. The organic mercury compounds have given promising results in the control of oat smuts but have not been superior to formaldehyde in the limited experiments conducted by the writers. For the control of barley smuts, however, they have been the most satisfactory fungicides.

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EXPLANATION OF PLATES

Plate XXV. Nakano Wase barley sown on Arlington Farm, Rosslyn, Virginia, in the fall of 1924. A. Seed soaked in .3 per cent solution of Semesan for 1 hour. B. Seed untreated.

Plate XXVI. Three hundred heads of Tennessee Winter barley from each of two plats sown on Arlington Farm, Virginia, with scarified, inoculated seed in the autumn of 1923. A. Seed soaked 1 hour in a .1 per cent solution of Corona No. 620. At the left, 96 per cent of sound heads and 4 per cent of smutted heads at right. Formaldehyde 1:320 solution (10-min. soak) reduced smuts to 5 per cent. B. Seed soaked 30 minutes in 1:320 formaldehyde and washed in clear water. At left, 76 per cent of sound heads and at right, 24 per cent of smutted heads.

Plate XXVII. Three hundred heads of Tennessee Winter barley from each of two plats sown on Arlington Farm, Virginia, with scarified, inoculated seed in the autumn of 1923. A. Seed dusted with Corona No. 40–S. At left, 89 per cent of sound heads and at right, 11 per cent of smutted heads. B. Seed soaked 1 hour in a 0.5 per cent solution of furfural. At left, 69 per cent of sound heads and at right, 31 per cent of smutted heads, compared with 27 per cent in the controls.

Plate XXVIII. Three hundred heads of Tennessee Winter barley from each of two plats sown on Arlington Farm, Virginia, with scarified, inoculated seed in the autumn of 1923. A. Seed soaked 1 hour in a .3 per cent solution of Chlorophol. The plants were smut free. A. 1 hour soak in either a .3 per cent solution of Semesan or a .2 per cent solution of Corona No. 620 also controlled the smuts perfectly in these experiments. B. Seed untreated at left, 73 per cent of sound heads and at right, 27 per cent of smutted heads.

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A PYRENOMYCETOUS LEAF SPOT OF BUR CLOVER

L. E. Miles

With Four Figures in the Text and Plates XXIX and XXX

On bur clover near Auburn, Alabama, there occurs very commonly a leaf-spot characterized by minute dark lesions dotted over the surfaces of the leaflets, stipules, and petioles. My attention was first called to this leaf-spot by Dr. E. F. Hopkins, who in 1920 made some preliminary notes and investigations regarding it. Dr. Hopkins has given me his notes, and I wish to take this opportunity to make acknowledgment to him of the great help which his sketches and suggestions have been to me.

The disease first appears in the early spring. Investigation has shown that the causal fungus is a species of *Pleosphaerulina*, similar to that on alfalfa, *Pleosphaerulina briosiana* Pol., and not greatly dissimilar from that on clover described by Dr. Hopkins from the campus of the University of Missouri, *Sphaerulina trifolii* Rostr. Evidence will be presented later which will show that it is different from either of these, and since no reference to it is to be found in the literature, the author has described it as a new species.

Although the disease is very common near Auburn, it is not conspicuous. It has not been encountered by the author in other localities. Many leaves are yellowed and killed by it, but its ravages are so greatly overshadowed by another leaf-spotting fungus, *Cercospora medicaginis*, that it very readily can be overlooked. The loss caused by it is probably not great, although it may cause considerable defoliation under favorable conditions.

SYMPTOMS

The first signs of the disease are minute black specks on the leaf-blades, stipules, and petioles. These lesions are very small and when few in number do not appear to injure the leaf, but when they are numerous the leaf tissue between the spots turns pale green to yellow. The spots then stand out in much greater contrast to the surrounding tissues, and the leaf has the appearance of being peppered. The spots do not enlarge very greatly, although occasionally they may reach a diameter of about one millimeter. Both the upper and lower sides of the leaves bear lesions, although they are usually more abundant on the lower surfaces and on the stipules and petioles. When the petioles become severely infected, the leaflets, even though they themselves may bear no lesions, turn pale yellow, and fall. The presence of numerous infections on the leaflets, with or without petiole

lesions, results in similar discoloration and defoliation. The contrast between these lesions and the surrounding pale yellow leaf tissue is very strong. Young lesions, even when few in number, are very clearly distinguished when the leaf is held between the eye and the light. Such young lesions are shown in Plate 1, Fig. 1, photographed by transmitted light. Later they enlarge somewhat and become easily visible to the unaided eye, without the use of transmitted light (Plate 1, Fig. 2). A small,

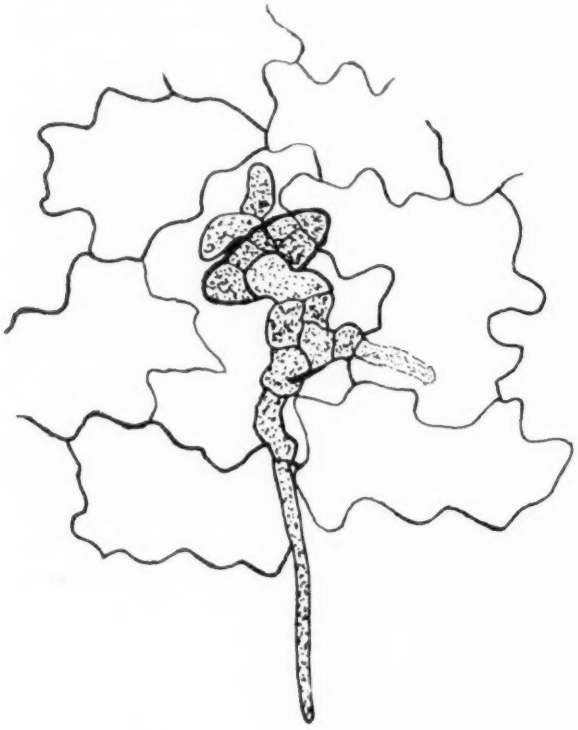

FIG. 1. Germinating ascospore on surface of leaf.

depressed, indefinitely delimited, gray to brown center is sometimes observed, although more commonly it is entirely absent. Under a hand lens the perithecia stand out clearly as small bright objects in which the ostiola can readily be distinguished.

Lesions have also been observed on the stems, peduncles, calyx, corolla, and even on the seed. The latter is very significant, as it indicates a very important possible means of transmission of the pathogene. Lesions on the seed look like small sclerotia, but they possess the structure of perithecia, although no asci or ascospores have ever been found in them. That they

are a means of transmitting the disease is clearly evident from the fact that viable cultures have frequently been obtained from them. Such seed lesions are shown in Plate 2, Fig. 2.

MORPHOLOGY

The mycelium of this fungus, as found naturally in infected tissue, is generally rather large in diameter, densely granular in content, and almost

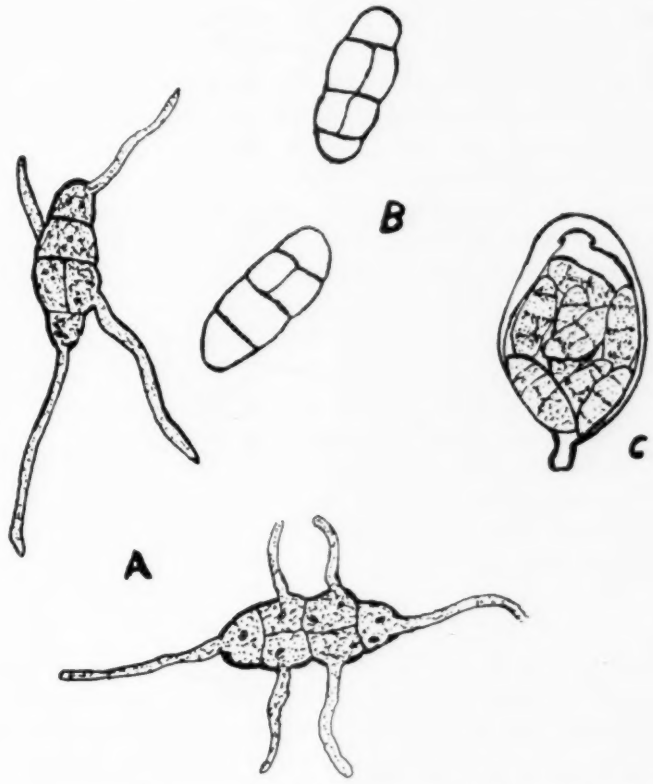

FIG. 2. (A) Germinating ascospores; (B) Ascospores; (C) Ascus containing spores.

invariably swollen at frequent intervals. In culture on most of the agars used in this experiment it is usually much the same but more uniform. The perithecia in nature are spherical or slightly flattened on the vertical axis and have proportionately large ostiola. The perithecial walls are smoky-brown in color, thin, membranaceous, and so transparent that the asci, and even the ascospores, can sometimes be distinguished through them when thoroughly mature. The perithecia are not beaked, the ostiola being

merely relatively large, approximately circular openings in the upper surface.

Young asci are pyriform in outline, becoming more or less broadly ovate with age (Fig. 2, C). In the younger stages the wall of the upper part is much thickened, gradually becoming thinner, but remaining proportionately quite thick until time for spore dispersal. There is some evidence of the presence of a pore, but usually it is not conspicuous. The asci are quite similar to those pictured by Hopkins for *Sphaerulina trifolii*, except that his are reversed, the thick portion being pictured as at the base. I am of the opinion that he is mistaken in this matter, and that in *S. trifolii* also the thickened portion of the ascus occurs at the top.

The ascospores are muriform, hyaline when young, but becoming honey-yellow at the time of, or shortly after, expulsion from the ascus. They are irregularly or subdistichously arranged. There are usually four cross walls, but it is quite common to find spores with only three (Fig. 2, B). Invariably one, and more commonly two, of the resulting spore segments are divided by a longitudinal septation. The spores are more or less symmetrical in outline, although the segments containing the muriform septation are inclined to bulge. Where four cross septations occur, the two halves of the spores are usually separated by a constriction slightly deeper and more conspicuous than elsewhere in the spore. The longitudinal septations usually occur in the middle segments, although both may occur on one side of the middle constriction; or, on the other hand, both may occur in the subterminal segments, having the central one or ones undivided. The mature spores are filled with granular protoplasmic contents and often contain several large oil drops.

ISOLATION

A considerable number of isolations have been made from leaf blades, petioles, stipules, peduncles, and seeds; and the same characteristic growth has been obtained in all cases. Growth from single ascospores has invariably been identical with that obtained from these isolations. Cultures from all sources were capable of infecting healthy leaves of bur clover. Owing to the fact that the Cercospora leaf spot occurs so generally on the same host plant, cultures of *Cercospora medicaginis* E. and E. are commonly obtained together with the Pyrenomycete. Mature perithecia are not obtained under ordinary conditions of growth but have been obtained under certain special conditions, as will be detailed later.

The fungus grew best on potato, and on cornmeal-glucose agars. It grew almost as well on prune agar. The growth is never rapid and is at first composed entirely of white mycelium. After a few days the center

of the colony begins to turn dark, owing to the formation of numerous black bodies which are of the nature of immature or aborted peritheeia. These bodies are filled with granular contents or occasionally with a substance resembling oil globules, which oozes out when they are crushed. The mycelium of the inner portion of the colony, at the time of formation of these bodies, takes on a golden brown to brown color, shading gradually to hyaline at the border. On prune agar, and less conspicuously so on cornmeal agar, the mycelium near the edge of the colony has a green tint. On potato agar the inner portion of the colony bearing the sclerotia or aborted peritheeia possesses a silvery luster, due to the excretion of minute drops of water. In appearance the colonies differ from those of *S. trifolii* in the presence of a much more evident and much wider sterile border, and in the smaller size of the sclerotial bodies.

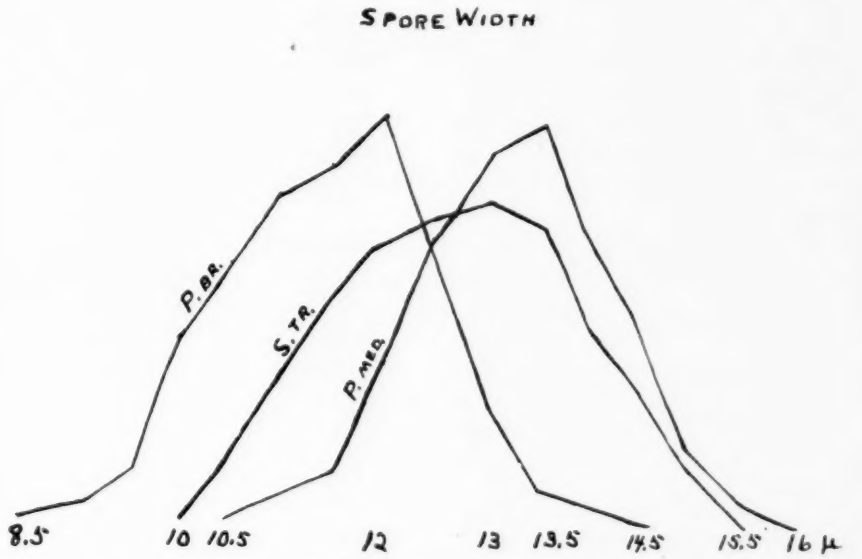

FIG. 3. Graph showing spore width variation in 200 ascospores of *Pseudoplea briosiana*, *Sphaerulina trifolii* and *Pseudoplea medicaginis*.

In two instances, cultures on potato agar, maintained at a temperature of from 7.5° to 10° C. for 22 days, matured spores, thereby showing the true character of the above-mentioned sclerotial bodies. The same experiment was repeated, but this time no spores matured. Some sclerotial structures, however, contained ovate, hyaline bodies which undoubtedly were immature asci. If they had been maintained for a longer time under the same conditions, there is little doubt that mature asci and spores would

again have been obtained. Jones (2) has reported similar results with *Pleosphaerulina briosiana* on alfalfa.

The fungus grew best at a temperature of about 20° C. No growth occurred at 35° C. as an upper limit. The lower limit of growth was not determined. It is somewhat peculiar that the only evidences of saltation appeared at the optimum temperature for development. On two different occasions wedge-shaped saltants appeared, two developing in one colony and one in another. These saltants were characterized by a browner color of the mycelium, the brown color extending entirely to the outer edge of sterile margin where color is usually entirely absent. The perithecial bodies were smaller in these saltation areas.

PATHOGENICITY

It was extremely difficult to obtain satisfactory infections from pure cultures of this fungus, owing to the fact that no spores were produced under ordinary conditions of growth. Fragments of mycelium and sclerotial bodies usually dried out before the pathogene could become established. However, in a number of instances, with careful manipulation, infections were secured in this manner, and typical lesions were produced. Re-isolation was successfully accomplished, thereby establishing the pathogenicity of the organisms.

Table 1 presents the results of inoculations of southern bur clover (*Medicago maculata*) with cultures secured both from seed and leaf tissue. It may be seen from Plate 2, Fig. 3, that these cultures are identical.

TABLE 1.—*Results of inoculation of southern bur clover with Pseudoplea from bur clover, observed 42 hours after inoculation*

Culture	Leaflets inoculated	Leaflets infected	Remarks
S[a] III	6	6	Grayish spots watersoaked, 0.4 cm.
S I	5	6	
A[b] III	5	5	Spots gray, irregular, watersoaked.
A IV	7	6	
A I	4	3	
A II	5	4	
S II	9	9	One infection slight.

[a] S = cultures isolated from seed.

[b] A = cultures isolated from leaf tissue.

In the main series of inoculations, however, it was found much more practical to use as a source of inoculum a quantity of leaves bearing large numbers of perithecia, suspended from the top of a bell jar which was in-

verted over a pot containing an uninfected plant. As a control, another pot of plants was covered with a bell jar in which no such source of inoculum was present. In all cases both bell jars were removed at the end of 42 hours.

Table 2 shows the results of inoculations in which 19 species and varieties of plants belonging to the genera *Medicago* and *Trifolium* were used. The numbers in the second column indicate approximately the relative amount of infection on the basis of 10, which represents the most severely infected.

TABLE 2.—*Results of inoculation of 19 species of Medicago and Trifolium with Pseudopleа from bur clover*

Host	Relative infection	Remarks
Medicago maculata	10	Spots very abundant, prominent on all parts of the plant except the stem.
Medicago hispida sardoa	10	Much as on *M. maculata*.
Medicago hispida compacta	8	Spots abundant, slightly less prominent.
Medicago hispida reticulata	8	As above.
Medicago hispida nigra	7	Spots numerous, prominent.
Medicago hispida confinis	6	Spots scattered, prominent, leaves only.
Medicago sativa	2	Slight watersoaked spots, developing no further.
Grimm alfalfa	2	As above.
Trifolium repens	2	Spots few, small, watersoaked.
Trifolium pratense (Red)	2	" " " "
Trifolium pratense (Mammoth)	2	" " " "
Trifolium hybridum	1	Mere watersoaked specks.
Trifolium reflexum	0	No trace of infection.
Trifolium incarnatum	0	" " " "
Trifolium procumbens	0	" " " "
Medicago ruthenica	0	" " " "
Peruvian alfalfa	0	" " " "
Turkestan alfalfa	0	" " " "
Argentine alfalfa	0	" " " "

In this experiment (Table 2) the bell jars were all removed at the end of 48 hours. At this time minute lesions were becoming evident on the leaves of most of the bur clover plants, while none of the control plants or those belonging to the genus *Trifolium* showed any traces of infection. After the bell jars were removed, the lesions on the plants of *Medicago maculata* and on all varieties of *Medicago hispida* continued to develop in size, while those on alfalfa and the clovers never attained more than a slight watersoaking or specking at the most.

It becomes evident from table 2 that southern bur clover is the most susceptible of the plants inoculated, and *Medicago hispida sardoa* only slightly less so. All other varieties of *Medicago hispida* are slightly less susceptible, but all are susceptible in the presence of abundant infection. It seems probable that none of the alfalfas or clovers are natural hosts of

this organism, since the spots, when they appeared at all, did not develop further than the pin-prick stage.

SEASONAL HISTORY

Infected plants were observed occurring naturally in the open in February, 1923; as early as January 4, 1924; and on January 24, 1925. On looking for the source of inoculum, it was found that numbers of old dead leaves around the base of infected plants were covered with numerous perithecia containing asci and mature ascospores. There seems to be little reason for doubting that much of the early infection on the young plants comes from such perithecia developed on the plants of the previous season. The minute spots on these plants, as mentioned previously, gradually enlarge and produce perithecia, thereby providing more inoculum, which pro-

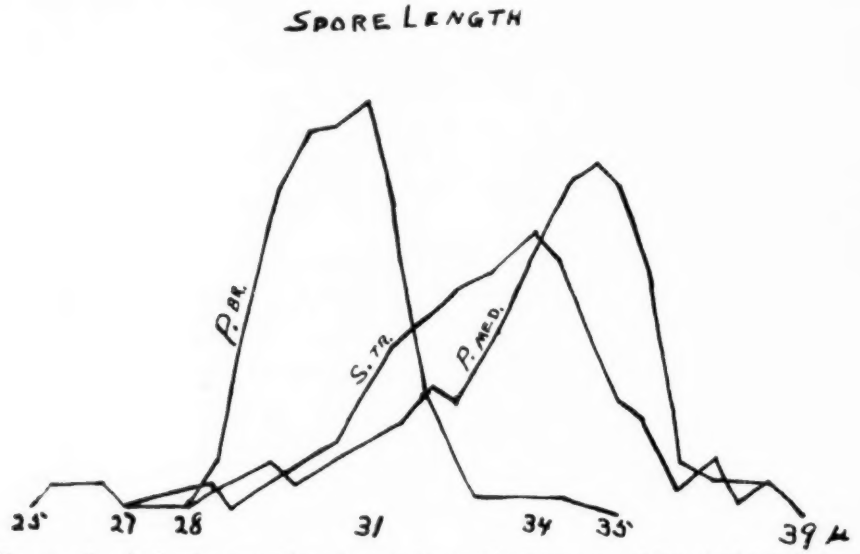

FIG. 4. Graph showing spore length variation in 200 ascospores of *Pseudoplea briosiana*, *Sphaerulina trifolii*, and *Pseudoplea medicaginis*.

duces infection throughout the season. No conidial stage has ever been observed which gave any indication of being connected with the fungus in question.

As mentioned previously, small sclerotia-like bodies, having more or less the structure of perithecia, but without asci or spores, were frequently observed on the seeds. These structures were identical in character with the bodies so abundantly produced in culture under ordinary temperature conditions, and which were proved to be immature or aborted perithecia.

capable of developing normal asci and ascospores under favorable conditions. It was proved repeatedly that these bodies were capable of transmitting the disease, as viable cultures were produced from them, which were identical in growth characteristics and pathogenicity with cultures isolated from other parts of the plant. Such seed have not been germinated to see if they would produce infected plants, but there would seem to be little doubt that they would do so. It is probable that they may serve as a capable and prolific agent in the spread of this disease in the field and from one locality to another.

PATHOLOGICAL RELATIONS

On coming in contact with the leaf surface, the ascospores germinate and send tubes directly through the epidermis. Any one or all of the cells of the spore may produce germ tubes (Fig. 2, A). These tubes may grow through the epidermis immediately or may wander over the surface for some distance before penetrating (Fig. 1). Sometimes the fungus produces a somewhat extensive layer of pseudoparenchymatous cells on the leaf before penetration. These are usually of a dark brown color, as viewed under the microscope, and are no doubt partly responsible for the dark color of the lesions. However, the palisade cells near the penetrating germ tube also take on a brown color which is also directly responsible for this appearance. The ascospore itself, at the time of expulsion, is hyaline or pale honey-yellow, but soon changes to a brown color similar to that of the resulting lesion. The empty wall persists for some time after infection has occurred, and it is by its presence that the nature and cause of many of the younger lesions are most readily determined. The color of the tissues around the lesion soon becomes so deep as to conceal effectively the details of further steps in its development. Most of the particular stages of spore germination, germ-tube penetration, and lesion development recorded above are much more readily observed after the leaves have been decolorized in acetic acid and alcohol. After such treatment, the muriform spores, or empty walls of the same, are to be observed in the center of almost every lesion.

SIMILAR LEAF-SPOTS ON CLOSELY RELATED HOSTS

The Sphaerulina leaf-spot of clover and the Pleosphaerulina leaf-spot of alfalfa very closely resemble this one on bur clover, both in macroscopic characters of the lesions and in the morphology of the causal organisms. The nomenclature of these two organisms has undergone in European literature a series of somewhat intricate and confusing changes. *Sphaerulina trifolii* was described on *Trifolium repens* in Denmark in 1899 by E.

Rostrup; *Pleosphaerulina briosiana* on *Medicago sativa* and *M. falcata* in Italy by Pollacci in 1901. In 1918, Von Höhnel established a new genus, *Pseudoplea*, of the Pseudosphaeriaceae, based on this latter fungus as a type, and it became *Pseudoplea briosiana* (Poll.) V. H. In 1921 the characters of this genus were amended by Petrak, who showed that Von Höhnel was wrong and that the fungus was truly Sphaeriaceous. The two species were united under the name *Pseudoplea trifolii* (E. Rostr.) Petr. It is evident however, as will be shown later, that in this union of the two species, cultural characters and inoculation experiments were not considered. The universal absence of a longitudinal cross wall in the spores of the clover organism, and the almost invariable presence of the same in the spores of the alfalfa organism are alone enough to establish the separate identities of the two, without consideration of this later evidence.

In many examinations of spores of the clover leaf-spot organism, grown on the host plant both as the result of inoculations and of natural infections, I have never observed the presence of longitudinal walls; neither does Hopkins in his description of the fungus in America, nor Rostrop in his original description, mention such walls. Specimens from Mycotheca Germanica No. 790 show none such; nor does Petrak make a direct statement that they are present, even when he places the fungus in the genus *Pseudoplea*, which he characterized as possessing them. Therefore, since the fungus can not belong to the same species or genus as the alfalfa leaf-spot organism, the author considers it best to leave it, for the present, under the name of *Sphaerulina trifolii* Rostr.

The asci of all are very similar in form, but measurements of a considerable number in each case show that there is a considerable difference in size, those of the organism causing the leaf spot on bur clover being the larger. The measurements shown in table 4 are the author's and are reached only after the examination of a considerable number of specimens. In the case of *Sphaerulina trifolii*, they agree very closely with those of Hopkins for the same fungus. The graphs (Figs. 3 and 4) show very clearly the relative spore sizes; each line, for both length and breadth, is made up of the measurements of 200 mature spores taken at random. It is seen here that the average spore size, as denoted by the apex of the curve, presents a much better basis of comparison than do the figures presenting the limits of variability. It will be seen that there is a very considerable difference in the sizes of the spores of *Pseudoplea briosiana* and the fungus on bur clover. Those of *Sphaerulina trifolii* occupy an intermediate position, but approach more nearly to the latter. The average size of the *P. briosiana* spore is $31 \times 12\mu$; that of *S. trifolii*, $34 \times 13\mu$; and that of the bur clover organism, $35 \times 13.5\mu$.

Table 3 shows the results obtained by inoculating twenty-two different species and varieties of clover, seven of alfalfa, and six of bur clover with spores of *S. trifolii* Rostr. The inoculum used in these tests was in all cases composed of leaves of *Trifolium repens* which contained large numbers of perithecia with mature asci and spores. As in the inoculation tests with the similar organism on bur clover, the bell jars were all removed at the end of forty-eight hours. Examinations of table 3 will show that only a few of the clovers and none of the alfalfas or bur clovers are natural hosts

TABLE 3.—*Results obtained by inoculating various species of Trifolium and related genera with Sphaerulina trifolii Rostr.*

Host	Relative infection	Remarks
Trifolium pratense (Mammoth)	10	Very abundant, prominent.
" " (Red)	8	Abundant, prominent.
T. repens	8	" "
T. reflexum	6	Much the same as on *T. subterraneum.*
T. subterraneum	6	Less abundant and less prominent than on *T. repens.*
T. hybridum	5	Lesions scattered but prominent.
T. alpestre	5	More abundant but less prominent than *T. hybridum.*
T. agrarium	5	Lesions scattered but prominent.
T. pannonicum	5	About as on *T. agrarium.*
T. squarosum	5	About as on *T. hybridum.*
T. striatum	4	Spots few but prominent.
T. fragiferum	4	Lesions scattered, not prominent.
T. medium	4	Scattered, not prominent.
T. incarnatum	4	" " "
T. carolinianum	2	Few, minute.
T. parviflorum	2	Lesions few, minute.
T. procumbens	2	More abundant but less prominent.
T. glomeratum	1	Mere trace.
T. dubium	1	Mere trace of infection. Few mere watersoaked spots, progressing no further.
T. lupinaster	1	Few mere watersoaked spots.
T. alexandrinum	0	No trace.
T. angustifolium	0	" "
Kansas alfalfa	3	Few scattered lesions, remaining small.
Grimm "	3	As on Kansas variety.
Turkestan "	2	Few, minute.
Peruvian "	1	Mere trace.
Argentine "	1	" "
Medicago sativa	2	Lesions few, minute, no perithecia developed.
M. ruthenica	2	Same as *Medicago sativa.*
M. maculata	2	Lesions scattered, minute.
M. hispida compacte	1	Mere trace of incipient infection.
M. " *nigra*	1	Few watersoaked specks.
M. " *reticulata*	0	None.
M. " *sardoa*	0	"
M. " *confinis*	0	"

for *Sphaerulina trifolii*, as on such hosts the infections, when evident at all, never progress beyond the incipient stage.

The case of the alfalfa leaf-spotting fungus, however, is different. It appears most clearly to belong to the Sphaeriaceous genus *Pseudoplea* Von Höhnel, as amended in 1921 by Petrak, and should henceforth be called *Pseudoplea briosiana* (Poll.) V. H. The name *Sphaerulina trifolii* Rostr. should be removed from the synonymy.

Comparative measurements of the perithecia of the three organisms (Table 4) show that those of *P. briosiana* on alfalfa are very nearly identical in size with those of the bur-clover organism, but that both are larger than those of *S. trifolii*.

TABLE 4.—*Comparative measurements of perithecia, asci and spores*

	Pseudoplea briosiana (Poll.) V. H.	*Sphaerulina trifolii* Rostr.	Bur clover organism
Perithecia	100–140 μ	80–125 μ	100–150 μ
Asci	68–83 × 34–40 μ	60–72 × 34–44 μ	62–92 × 38–45 μ
Spores	25–35 × 8.5–14.5 μ	27–39 × 10–15.5 μ	28–39 × 10.5–16 μ

After careful consideration of these differences in morphology, macroscopic appearance, and pathogenicity in the fungi under consideration, it has seemed clear to the author that the bur-clover organism is distinct from either of the others, belonging to the same genus as the one causing the similar disease on alfalfa, *Pseudoplea briosiana* (Poll.) V. H., but being a distinct species. The name *Pseudoplea medicaginis* sp. nov. is therefore suggested for this organism.

Pseudoplea medicaginis sp. nov.

Spots on leaves none or pale yellow to brown, indefinite in outline and size. Minute black or dark brown lesions scattered over these lighter areas or over the normally colored leaflet give it a peppered appearance. Such lesions also occur on peduncles, petioles, calyx, corolla, and seeds. On the seed they have the appearance of minute sclerotia. Perithecia numerous, spherical or slightly flattened, with large round ostiole, 100–150μ. The walls are smoky brown in color, thin, membranous, and almost transparent. Asci are few in number, pyriform in outline, or in age broadly ovate, with walls much thickened toward the apex, 63–92 × 38–45μ. Spores are eight in number, muriform, irregularly or subdistichously arranged, with four or more, rarely three, cross walls, and one, or more commonly two, of the segments divided by a longitudinal septation. The spores are first greenish hyaline in color but at maturity become almost honey yellow. They

measure 28–39 × 10.5–16μ. Habitat: On leaves, stems, peduncles, petioles, calyx, corolla, and seeds of *Medicago maculata* about Auburn, Alabama.

Pseudoplea medicaginis sp. nov.

Maculis in foliis nullis vel arescente pallescentibus, indeterminatis; perithecciis numerosis, in parte folii ochraceolutescente, sparsis vel subgregariis, membranaceis, immersis, dein erumpentibus, globoso-depressis, glabris, 100–150μ, ostiolo latiusculo impresso perforatis; ascis paucis, aparaphysatis, octosporis, crasse pyriformibus, apice valde incrassatis, 63–92 × 38–45μ; sporidiis oblongo-fusoideis, utrinque obtusiusculis, initio chlorino-hyalinis, dein pallide brunneo-flavis, sursum in ascis irregulariter distichis, deorsum monostichis, muriformibus, transverse 3–4 septatis, loculis 1–2 septis longitudinalibus divisis, 28–39 × 10.5–16μ.

Hab: In foliis, caulibus, petiolis, pedunculis, sepalis, corollis, etiam semenibus Medicaginis maculatae, Auburn, Alabama.

SUMMARY

Evidence is presented in this paper to show that a Pyrenomycetous fungus producing a leaf spot on bur clover near Auburn, Alabama, is distinct from either of those causing similar spots on alfalfa and clover respectively, although the host plants are closely related and the lesions produced are very similar macroscopically.

Sclerotioid bodies on the seed were capable of producing viable cultures on agar.

Similar bodies, produced in culture, were proved to be immature perithecia, capable of developing mature asci and ascospores under favorable conditions.

All species and varieties of bur clover inoculated were found to be susceptible to the fungus, while none of the alfalfas or clovers produced typical lesions. The fungus is described as a new species, *Pseudoplea medicaginis* sp. nov.

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EXPLANATION OF PLATES

PLATE XXIX

FIG. 1. Lesions on young leaves photographed by transmitted light.

FIG. 2. Lesions on old leaves and petioles.

PLATE XXX

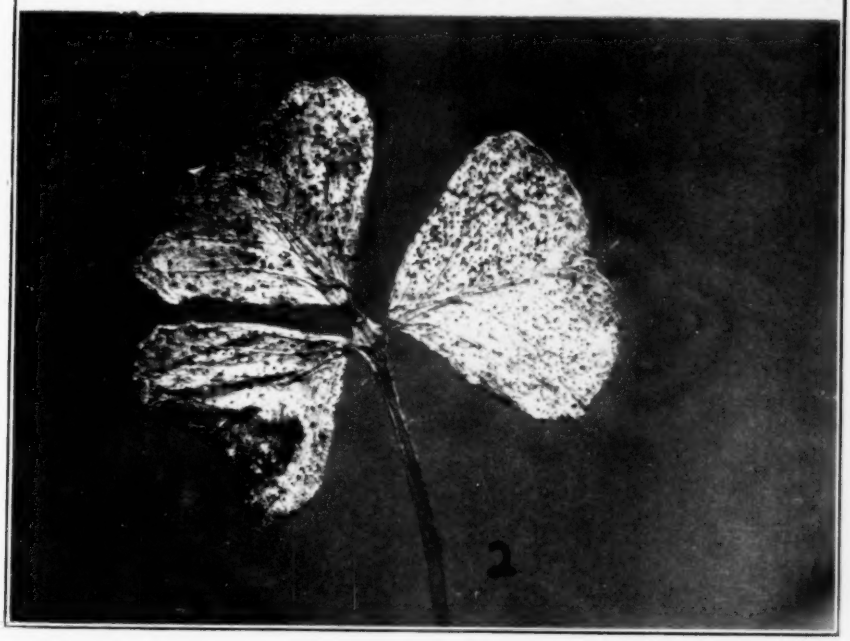
FIG. 1. Seed free from infection.

FIG. 2. Seed showing on their surface lesions having appearance of small sclerotia.

FIG. 3 (A). Culture of *Pseudoplea medicaginis* sp. nov. on cornmeal agar, isolated from leaf tissue.

FIG. 3 (B). Culture of *Pseudoplea medicaginis* sp. nov. on cornmeal agar, isolated from seed lesion.

1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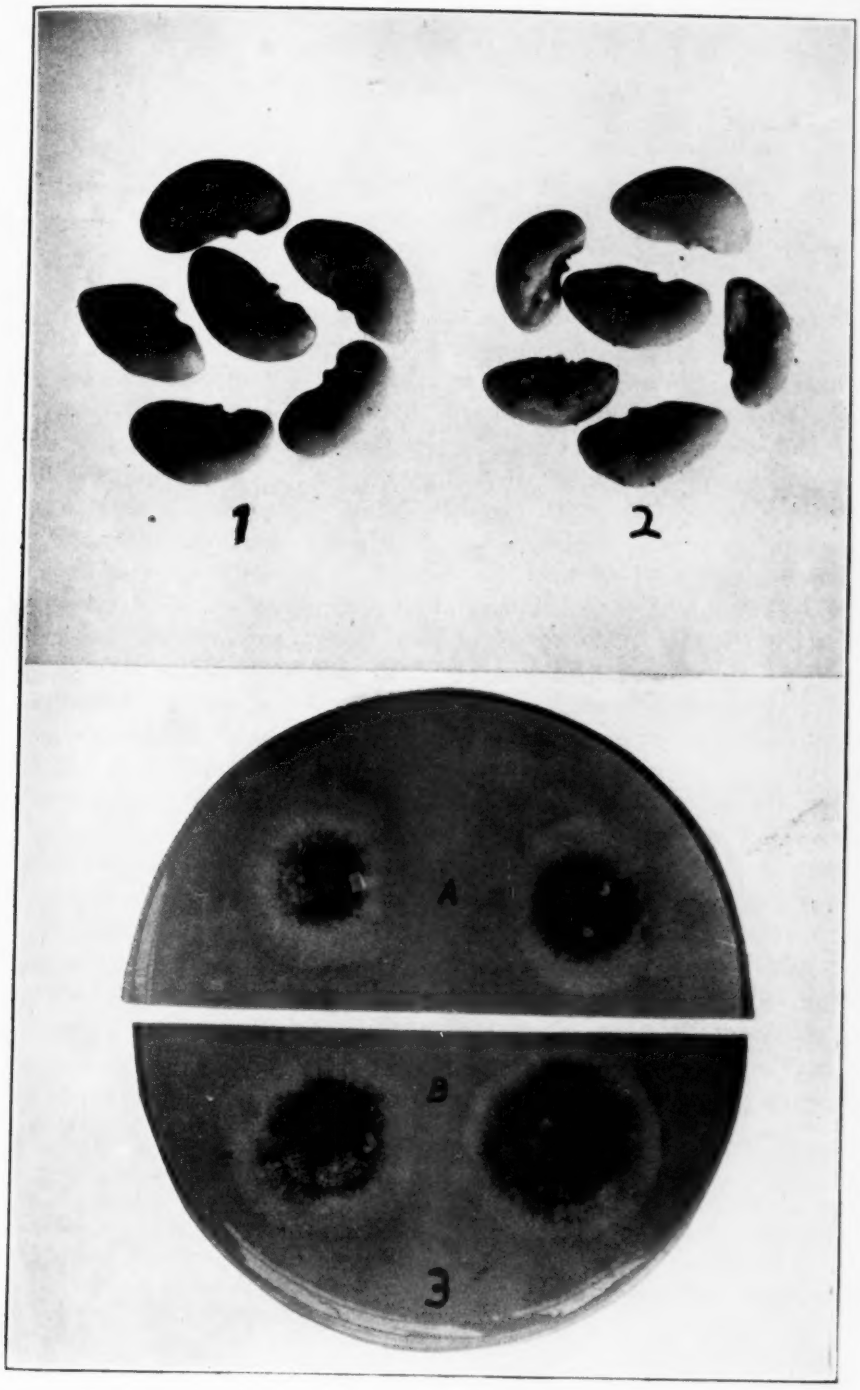
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WEBSTER, A COMMON WHEAT RESISTANT TO BLACK STEM RUST[1]

E. C. Stakman, M. N. Levine and Fred Griffee[2]

With One Figure in the Text

Introduction

Webster, C. I.[3] 3780, a recently named (2, p. 66) variety of common wheat, *Triticum vulgare* Vill., introduced from Russia by the United States Department of Agriculture in 1913, apparently is resistant to more physiologic forms of *Puccinia graminis tritici* (Pers.) Eriks. and Henn. than any other common wheat yet tested in the United States. This variety seems to be so generally resistant that it is interesting and may be important. It is an awned, hard red spring variety. Although Webster wheat is not a very desirable type, it probably is potentially valuable as a parent of rust-resistant hybrids. This is particularly true because no varieties of *T. vulgare* are known to be resistant to all of the thirty-nine physiologic forms of *P. graminis tritici* thus far found in North America. For this reason, breeders have crossed many varieties of *T. durum* Desf. and *T. dicoccum* Schrk. with those of *T. vulgare*, hoping to obtain hybrids resistant to most physiologic forms. While evidently it is possible to combine the rust-resistant characters of some of the durum and emmer wheats with the botanical characters of common wheats, certain difficulties have been encountered (3). The common wheats have forty-two chromosomes (diploid), the durum and emmer varieties have twenty-eight, and einkorn has fourteen. When varieties with different chromosome numbers are crossed, many segregates are eliminated by sterility due to chromosome incompatibility (5, 8, 9, 14). Therefore there is a tendency for the progeny to revert to one or the other of the parental types. There is a high degree of sterility in crosses between durum wheat or emmer and the common wheats, and there also is some linkage between durum and emmer characters.

[1] Cooperative investigations between the Bureau of Plant Industry, U. S. Department of Agriculture, and the Agricultural Experiment Station of the University of Minnesota. Published with the approval of the Director as Paper 541 of the Journal Series, Minnesota Agricultural Experiment Station.

[2] Seed of this wheat was sent to the writers by E. S. McFadden, of Webster, Day County, South Dakota, who first observed its resistance at Highmore, S. D., in 1917. A brief account of Mr. McFadden's observations has been published in The Dakota Farmer 45: 102. 1925.

[3] C. I. = Accession number of the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

and rust resistance. This makes it necessary to use many individuals in breeding work, and it increases the difficulty of obtaining the desired results. Hence it is advantageous to have several resistant varieties of common wheat having forty-two chromosomes.

KNOWN RUST-RESISTANT VARIETIES OF COMMON WHEAT

It often is stated that Kanred and Kota are the only varieties of common wheat known to be resistant to black stem rust. This statement is not quite accurate. There are at least thirty-nine physiologic forms of *Puccinia graminis tritici*, but neither Kanred nor Kota, nor any other common wheat, is known to be resistant to all of them. The resistance of a variety should be considered with reference to particular physiologic forms. Marquis, generally considered to be susceptible to black stem rust, is very resistant to thirteen of the thirty-nine physiologic forms of *P. graminis tritici*. Marquis rusts commonly in the field in the upper Mississippi Valley, and in various other parts of the United States; but in some of the Gulf states, and in certain sections in the Pacific Northwest, where it is not grown commercially, it is usually resistant. Kanred is immune from eleven and resistant to seven of the thirty-nine forms, whereas Kota is immune from two and resistant to eighteen. While Kanred and Kota are the most generally resistant of the common wheats grown in the upper Mississippi Valley, some physiologic forms can infect them normally, and they sometimes are rusted heavily in the field. Hence it is important to obtain other common wheats resistant to more physiologic forms than those to which Kota, Kanred, and Marquis are resistant. Webster is resistent to all of the physiologic forms with which it has thus far been inoculated.

COMPARATIVE RESISTANCE OF WEBSTER AND OTHER COMMON WHEATS

Webster has been inoculated with nineteen physiologic forms of *P. graminis tritici*, including some of the most virulent. The other forms were not available. Table 1 summarizes the reactions of the following wheats to nineteen physiologic forms: Webster, C. I. 3780; Marquis, C. I. 3641; Kanred, C. I. 5146; Kota, C. I. 5878; Mindum, C. I. 5296; and Acme, C. I. 5284. The last two varieties listed are durums which often are resistant in the field and are included for comparison.

It will be seen from table 1 that Webster is not really susceptible to any of the nineteen physiologic forms with which it was inoculated. Marquis is susceptible to fourteen of them, Kanred to eight, Kota to twelve, Mindum to thirteen, and Acme to eighteen. Arnautka, C. I. 4072, often is considered to be resistant in the field, but it is susceptible to thirteen of the nineteen forms to which Webster is resistant. Even Vernal emmer, C. I.

TABLE 1.—*Comparative reactions of Webster, Marquis, Kanred, Kota, Mindum, and Acme to nineteen physiologic forms of Puccinia graminis tritici in the greenhouse*

Physiologic form	Variety and reaction[a]					
	Webster C. I. 3780	Marquis C. I. 3641	Kanred C. I. 5146	Kota C. I. 5878	Mindum C. I. 5296	Acme C. I. 5284
1	3 –	4 –	0	3 +	1	3 ++
3	3	4 –	4 =	3 +	1 =	3 ++
9	3 =	4 –	0	3 ++	4 =	3 ++
11	3c	4 =	3 ++	3 +	4 =	3 ++
15	2 – to 3 –	4 –	4 =	3 ++	4 =	3 ++
17	2 – to 3 –	4 –	0n	3 +	4 =	3 ++
18	3 – c–	4 –	4 =	3 ++	1 =	3 ++
19	2 to 3	2 –	0f	3 –	4 =	3 ++
21	2 to 3c+	4	0	3 ++	4 –	3 ++
27	0f	2	0	0n	1	3 ++
29	2 ± n to 3n+	4 –	0	3	X ±	X +
30	3 –	4	0n	3 ++	X ±	X +
32	3 =	4 =	4 =	3 +	X ±	X +
33	2 + c	2	4	1 +	1 –	3 ++
34	3 =	4 –	4 –	4 =	4 =	3 ++
36	3n	4	4 –	3 ++	1 =	3 ++
37	3 =	4 –	0	3 ++	4 =	3 –
38	3 = c+	2 =	4 +	3 +	X +	X +
39	2c+	2 +	4	3 +	3 +	3 +

[a] Explanation of symbols: 0, immune; 1 and 2, very resistant; 3 and 3 –, moderately resistant; 3 +, moderately susceptible; 4 = to 4 +, very susceptible; X, indeterminate (probably susceptible); c, chlorosis; n, necrosis; f, hypersensitive flecks. The minus and plus signs indicate fluctuations within the type; thus, 3 = indicates a very weak type 3 infection; 3 ++ indicates a very heavy type 3 infection; a ± after the X indicates that small and large pustules are about equally numerous. For further details see Stakman and Levine (11).

3686, which is almost immune from many forms, is completely susceptible to four of the nineteen.

The possible value of Webster in developing rust-resistant varieties is evident from the data given in table 2. It is resistant to five forms to which none of the other common wheats are known to be resistant. It is likely that it also is resistant to other forms. It will be seen from table 2 that no common wheat is known to be resistant to Forms 12, 13, and 20. However, the known resistant common wheats between them are resistant to thirty-six of the thirty-nine physiologic forms which the writers have isolated. The importance of this fact for breeding work is obvious.

THE TYPE OF RESISTANCE OF WEBSTER

Webster is not entirely immune from any of the physiologic forms with which it has been inoculated, although it is almost immune from the rather

TABLE 2.—*Physiologic forms of Puccinia graminis tritici, and varieties of common wheat resistant to them*

Physiologic forms and resistant common wheats							
1	2	3	4	5	6	7	8
Webster Kanred	Marquis Kanred Kota	Webster	Marquis Kanred Kota	Kanred	Marquis Kanred Kota	Marquis Kota	Kanred
9	10	11	12	13	14	15	16
Webster Kanred	Marquis Kota	Webster			Marquis Kanred Kota	Webster	Marquis Kanred Kota
17	18	19	20	21	22	23	24
Webster Kanred	Webster	Webster Marquis Kanred		Webster Kanred	Kota	Marquis Kanred Kota	Kanred Kota
25	26	27	28	29	30	31	32
Kota	Kanred Kota	Webster Marquis Kanred Kota	Marquis Kanred Kota	Webster Kanred	Webster Kanred	Kota	Webster
33	34	35	36	37	38	39	
Webster Marquis Kota	Webster Marquis Kota	Kota	Webster	Webster Kanred	Webster Marquis	Webster Marquis	

weakly parasitic Form 27. The type of infection of the other forms ranges from 2 to 3. It will be noted from table 1 that many of the forms cause a type 3 infection, but a variety which consistently develops a type 3 infection in the greenhouse is not likely to be injured much in the field. The type 3 was placed in the susceptible class by Stakman and Levine (11). From the standpoint of parasitism, the writers still think this is correct, because the genetic factors for the development of the type 3 infection seem to be more closely related to those for a type 4 than to those for types 2 and 1. But the type 3 could equally well be placed in a moderately resistant class.

Many uredinia may develop on Webster, but they are always small and seldom coalesce. Often they are surrounded by chlorotic or even necrotic areas, which is an additional indication of resistance. While this variety undoubtedly will rust in the field, it is unlikely that it will be injured severely unless it is susceptible to some of the forms to which its reaction is not yet known. The type of reaction seems to be somewhat similar to that of White Tartar oats, C. I. 551. White Tartar is not immune from the physiologic forms of *P. graminis avenae* Erikss. and Henn., which are known to occur in the United States, but it is resistant to them. They cause a type 3 infection, but the variety is sufficiently resistant to escape injury in the field. Apparently Webster reacts similarly.

From unpublished results obtained by Helen Hart,[4] it seems unlikely that Webster will be injured severely by stem rust, because its resistance seems to be due, at least partially, to the fact that there is a large amount of sclerenchyma in the stem. The collenchyma bundles are small. Consequently the rust is limited to small areas and cannot cause much injury. Hursh (4) recently has discussed in detail this type of resistance.

REACTION OF WEBSTER TO RUST IN THE FIELD

Webster was grown in the Minnesota rust nursery for the three years, 1915 to 1917, inclusive. The percentages of stem rust were as follows: 1915, 20 per cent; 1916, 65 per cent; 1917, 70 per cent with 50 per cent on the peduncles. These notes were taken by Messrs. J. H. Parker and O. S. Aamodt, who were in charge of the nursery during those years. Mr. McFadden observed that Webster was more resistant than Kota in six of the eight years during which he has had it under observation in South Dakota. It also has been resistant to orange leaf rust in the field.

[4] Unpublished results of cooperative investigations between the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, and the Agricultural Experiment Station of the University of Minnesota.

REACTION TO ORANGE LEAF RUST

Webster also was inoculated in the greenhouse with fifteen collections of *Puccinia triticina*, including at least four or five physiologic forms. These collections were obtained from Minnesota, North Dakota, Missouri, Kansas, and Texas. Webster was very resistant to some collections and moderately susceptible to others. The type of infection varied from 0 to 4 −. Nine of the collections produced a type 3 infection; two, 3 + to 4 −; two, 1 =; and two caused flecks only. It seems likely, therefore, that Webster may be valuable also as a parent in breeding for resistance to the orange leaf rust.

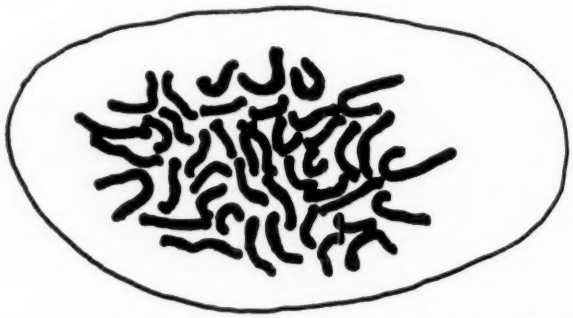

FIG. 1. Webster, C. I. 3780. Camera lucida drawing of a root-tip cell. ×1700. The chromosome number was found to be 42 in the somatic cells.

CHROMOSOME NUMBER OF WEBSTER WHEAT

Wheat species have been placed in three groups on the basis of taxonomic relationships by Schulz (10), and in similar groups by Tschermak (13), as a result of a study of genetic relationships. More recently, as mentioned above, the species have been placed in similar groups on the basis of their chromosome numbers (5, 8). Usually wheat varieties can be placed in one of the three groups with certainty on an inspection of morphologic characters. A variety occasionally is found, however, which is apparently intermediate between the durum and vulgare types, as is the case with Sevier wheat (1, 12), for example. Webster, while a common wheat in most characters, has a more pronounced keel than most of them and is somewhat spelt-like in appearance. In crosses made with common wheats by Mr. McFadden, the Webster variety behaved as a common wheat. As the chromosome number of a variety may be considered a fairly accurate criterion of its genetic relationships, it seems desirable to record the chromosome number for any new discoveries which are of interest from the breeding standpoint.

The chromosome number of Webster was determined from a study of root tip sections. The root tips were killed with modified Bouin's killing

fluid, commonly known as B–15. They were carried through in the usual manner and imbedded in paraffin. Transverse sections were cut at a thickness of 10 microns. The sections were stained with Haidenhain's iron-alum haematoxylin. In good preparations it is a simple task to differentiate types with 28 chromosomes and 42 chromosomes. It is more difficult to determine accurately the actual number of a variety which can be placed at approximately 42. Counts were made of several cells and three camera lucida sketches were made from the cell, represented in figure 1. In all cases division figures were selected which apparently contained all of the chromosomes entire. That is, neighboring sections were scanned carefully to note the presence or absence of pieces of chromosomes which might have been cut from the figure being drawn. Counts were made only from cells in which the chromosomes were intact. The number of chromosomes was found invariably to be forty-two.

SUMMARY

1. Webster, C. I. 3780, a recently named variety of common wheat, *Triticum vulgare*, appears to be resistant to more physiologic forms of *Puccinia graminis tritici* than any other common wheat now known.

2. E. S. McFadden, who has grown Webster experimentally for several years in South Dakota, first called attention to its rust resistance.

3. Webster is not a desirable type of hard red spring wheat for commercial growing.

4. Webster probably will be valuable in breeding for rust resistance, because it is resistant to some physiologic forms of *P. graminis tritici* to which no other common wheat is known to be resistant. In attempts to produce desirable, rust-resistant wheats, resistant varieties of durum and emmer have been crossed with common wheats. However, there is some linkage between durum and emmer characters and rust resistance. And, owing to chromosome incompatibility, the percentage of sterility is high, necessitating the use of large numbers of plants. This makes the work of developing resistant varieties rather difficult.

5. Webster has been inoculated with nineteen physiologic forms of *P. graminis tritici* and is relatively resistant to all of them. It is resistant to five physiologic forms to which no other variety of common wheat is known to be resistant.

6. Apparently the rust resistance of Webster is due to the large amount of sclerenchyma in proportion to collenchyma in the stem. For this reason it seems likely that it will be resistant to all physiologic forms of *P. graminis tritici*.

7. There are only three physiologic forms of *P. graminis tritici* so far found in North America to which no *vulgare* wheat is known to be resistant. Webster has not yet been inoculated with these three forms.

8. If Webster is resistant to the three forms mentioned above, it will be possible to use *vulgare* wheats entirely as parents in crosses for rust resistance.

9. Webster has forty-two chromosomes and therefore is classed as a common wheat, although the spike is somewhat spelt-like and the glume has a well developed keel.

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THE REACTION OF SELFED LINES AND CROSSES OF MAIZE TO USTILAGO ZEAE[1,2]

F. R. Immer and J. J. Christensen

INTRODUCTION

It has been learned from previous investigators (1, 2, 3) that selection in self-fertilized lines can be used to isolate lines of maize which differ markedly in their manner of reaction to *Ustilago zeae* (Beckm.) Ung. It was apparent also that it was comparatively easy to obtain selfed lines which were homozygous, or nearly so, and which were either highly resistant, highly susceptible, or intermediate in their reaction. The present paper gives the results of an investigation, which is a continuation of studies previously reported, on the mode of reaction to smut in the F_1 and F_2 generations and in backcrosses where selfed lines of known inheritance were used as parents.

EXPERIMENTAL RESULTS

The probable error method was used to determine what differences could be considered significant. The probable error in percentage for the amount of smut infection of two plots systematically replicated, as calculated by the pairing method (4), was determined for the groups of strains with a percentage of infection between two arbitrary limits. The probable error of each such class, or group of strains, and the number of pairs in the class from which the probable error was calculated are given in table 1.

TABLE 1.—*The probable error in percentage for smut infection of selfed strains and crosses differing in percentage of smut, as calculated by the pairing method*

Total smut in class, per cent	Pairs in class	Probable error, per cent
0.0 to 10.0	7	53.74
10.0 to 20.0	14	26.89
20.0 to 30.0	19	14.36
30.0 to 40.0	9	13.99
40.0 to 50.0	12	7.45
50.0 to 60.0	9	10.11
60.0 to 100.0	11	5.23

[1] The authors wish to express their appreciation for the helpful suggestions of Drs. H. K. Hayes and E. C. Stakman in planning and conducting this investigation.

[2] Published with the approval of the Director as Paper No. 551 of the Journal Series of the Minnesota Agricultural Experiment Station, University Farm, St. Paul, Minn.

The probable error in percentage decreased rapidly as the percentage of smut infection in the strains increased. While the actual deviation from the average in the low smut strains was smaller than in the high smut strains, the deviation in percentage was far greater in the low than in the high smut strains. The probable error for the entire experiment, as calculated by the pairing method, was 17.1 per cent. It is obviously unfair to use this percentage as the probable error for each strain, regardless of the percentage of smut, because such a probable error would be too low for the low smut strains and too high for the high smut strains. The probable errors of the strains in the 1924 test were calculated, therefore, according to the percentage of probable error for the class into which they fell, as given in table 1. The probable errors for the previous years, when used, were those reported by Hayes et al. in 1924.

REACTION OF PARENT LINES

Eight parent lines, which had proven to be apparently homozygous for a particular type of smut reaction under artificially induced epidemic conditions, were used to make the crosses for this inheritance study. The varieties Minnesota No. 13, Rustler, and Longfellow were used, and all crosses were made within a variety. The percentage of total and of ear smut infection of these parent lines for the years 1921 to 1924, inclusive, is given in table 2. Ear smut was calculated separately, because of its economic importance.

In general, the lines produced a relatively uniform percentage of smut from year to year. Since smut is due to a disease-producing organism which is dependent on environmental conditions for dissemination of the spores and consequent chance for infection, it is to be expected that there will be some variability in the percentage of smut produced. These parent lines were classified as high, medium, and low smut strains, depending on the average percentage of infection. Thus, the lines with an average of 0 to 15 per cent of total smut infection were classed as low smut strains; the lines with an average infection between 15 and 50 per cent of smut were classed as medium; and those with an average of over 50 per cent total smut infection were classed as high smut strains. While varying somewhat in percentage of smut from year to year, these parent lines quite uniformly stayed within their class limits.

REACTION OF CROSSES

The F_2 and back-crosses were made in 1923. In eight of the back-crosses it was possible to compare the percentages of smut infection of the progeny from crosses in which the F_1 was used as the male and from those

TABLE 2.—*The percentage of total and ear smut infection of self-fertilized strains of corn which were used as parent lines for subsequent crosses*

Variety	Cult. No.	Per cent of total smut					Per cent of ear smut				
		1921	1922	1923	1924	Average	1921	1922	1923	1924	Average
Minnesota No. 13	15	58.0	62.8	85.5	74.4	70.2 ± 3.9	32.0	26.6	16.8	36.5	28.0
" "	17	10.5	65.6	14.0	.....	30.0 ± 2.2	0.0	0.0	2.0	.....	0.7
" "	19	14.0	40.0	21.8	29.4	26.3 ± 1.7	0.0	4.0	4.5	0.0	2.1
Rustler	21	84.5	100.0	98.0	83.8	91.6 ± 5.0	11.2	21.3	28.0	56.0	29.1
"	23	28.5	2.5	12.1	33.4	19.1 ± 1.2	14.4	0.0	4.0	8.0	6.6
"	26	2.0	2.2	12.6	4.3	5.3 ± 0.8	0.0	0.0	0.0	0.0	0.0
Longfellow	46	4.5	19.4	7.4	15.0	11.6 ± 1.0	0.0	2.5	0.0	0.0	0.6
"	48	65.0	84.0	67.1	27.3	60.9 ± 4.0	12.4	6.0	30.6	5.5	13.6
"	51	12.0	27.7	69.1	52.4	40.3 ± 2.4	4.8	9.7	13.0	47.6	18.8

in which the F_1 was used as the female parent. A comparison of the results of these reciprocal crosses is given in table 3.

TABLE 3.—*A comparison of the percentage of total smut in comparable crosses when the F_1 was used as the staminate and when used as the pistillate parent*

Cross	Per cent smut		
	F_1 as ♂	F_1 as ♀	F_1 as ♂ minus F_1 as ♀
(Low × Med.) × Low	9.5 ± 5.1	6.1 ± 3.3	+ 3.4 ± 6.1
(Low × High) × Low	18.7 ± 5.0	26.2 ± 3.8	— 7.5 ± 6.3
(Low × Med.) × Med.	9.6 ± 5.2	10.8 ± 2.9	— 1.2 ± 6.0
(Low × High) × High	72.8 ± 3.8	53.0 ± 5.4	+ 19.8 ± 6.6
(Med. × Med.) × Med.	32.9 ± 4.6	30.0 ± 4.2	+ 2.9 ± 6.2
(Med. × Med.) × Med.	22.8 ± 3.3	22.5 ± 3.2	+ 0.3 ± 4.6
(Med. × High) × Med.	55.0 ± 5.6	45.2 ± 3.4	+ 9.8 ± 6.6
(Med. × High) × High	74.0 ± 3.9	74.3 ± 3.9	— 0.3 ± 5.5

The difference between each of the above crosses and its reciprocal was within three times the probable error. In 7 of the 8 comparisons the differences did not exceed one and one-half times the probable error. It may therefore be safely concluded that the factors for smut resistance or susceptibility are transmitted in the same manner in both male and female gametes.

In table 4 is summarized the percentage of total and of ear smut infection of the parent lines and of the F_1 and F_2 crosses of these lines.

In the F_1 crosses the percentage of smut infection tended to be intermediate. In the cross between the strains classed as medium (17 x 19), and between the medium and low strains (23 x 26), the F_1 was somewhat less severely infected than either parent. It appears possible that infection is somewhat less in vigorous crosses than in selfed lines, although it is also evident that smut reaction is dependent on definitely transmissible genetic factors. With a complete, or almost complete, lack of dominance it is to be expected that the F_2 would produce approximately the same percentage of smut infection as the F_1. In 4 of the 6 crosses, the difference between the F_1 and F_2 was less than twice its probable error, and in all crosses the difference was less than three times its probable error.

In none of the 19 backcrosses was the percentage of smut infection obtained significantly larger or smaller than that of the average of the parents. It may be safely concluded from these data that there is no definite dominance of resistance or susceptibility to smut infection.

In studying the inheritance of reaction to ear smut, it is found that three of the F_1 crosses were more severely, and three less severely, infected

than the average of the parents. Five of the six F_2 crosses produced a higher percentage of ear smut infection than did the F_1. Of the 19 backcrosses, 10 produced a slightly higher percentage of smut than either parent, and the remaining 9 were intermediate in reaction.

TABLE 4.—*A summary of the reactions of parent lines and of F_1 and F_2 crosses to attacks of Ustilago zeae*

Variety	Parent line or hybrid	Class for smut reaction of parents	Generation selfed or cross	Per cent total smut	Per cent ear smut
Minn. No. 13	17	Medium	S	30.0 ± 4.2	0.7
" "	19	Medium	S	26.3 ± 3.7	2.1
" "	17 × 19	Med. × Med.	F_1	20.6 ± 3.0	3.3
" "	17 × 19	Med. × Med.	F_2	26.2 ± 3.8	7.7
Minn. No. 13	15	High	S	70.2 ± 3.7	28.0
" "	17	Medium	S	30.0 ± 4.2	0.7
" "	15 × 17	High × Med.	F_1	45.8 ± 3.4	17.3
" "	15 × 17	High × Med.	F_2	52.2 ± 5.3	22.1
Rustler	21	High	S	91.6 ± 4.8	29.1
"	26	Low	S	5.3 ± 2.8	0.0
"	21 × 26	High × Low	F_1	25.0 ± 3.6	4.5
"	21 × 26	High × Low	F_2	34.4 ± 4.8	11.1
Rustler	23	Medium	S	19.1 ± 5.1	6.6
"	26	Low	S	5.3 ± 2.8	0.0
"	23 × 26	Med. × Low	F_1	2.8 ± 1.5	0.0
"	23 × 26	Med. × Low	F_2	12.9 ± 3.5	2.4
Longfellow	46	Low	S	11.6 ± 3.1	0.6
"	48	High	S	60.9 ± 3.2	13.6
"	46 × 48	Low × High	F_1	61.0 ± 3.2	17.0
"	46 × 48	Low × High	F_2	47.5 ± 3.5	12.0
Longfellow	46	Low	S	11.6 ± 3.1	0.6
"	51	Medium	S	40.3 ± 3.0	18.8
"	46 × 51	Low × Med.	F_1	24.7 ± 3.5	6.5
"	46 × 51	Low × Med.	F_2	16.8 ± 4.5	10.5

REACTION OF LOW SMUT STRAINS SELECTED UNDER NORMAL FIELD CONDITIONS WHEN TESTED UNDER SMUT EPIDEMIC CONDITIONS

Fourteen selfed lines of corn which had produced a low percentage of total smut in the regular corn breeding nursery for several years were grown in the smut inheritance plot in 1924. The purpose of this was to test the reliability of selection of low smut strains under normal field conditions when compared with their reaction under artificially induced smut epidemic conditions. The results are given in table 5.

TABLE 5.—*The percentage of smut infection of strains of corn which had given a low smut infection for several years in the regular corn-breeding nursery*

Cult. No.	Variety	Per cent smut infection	
		Total	Ear
73	Minnesota No. 13	2.0 ± 1.1	0.0
74	"	43.2 ± 3.2	3.9
75	"	26.3 ± 3.8	13.2
76	Rustler	12.2 ± 3.3	0.0
77	"	13.0 ± 3.5	0.0
78	"	71.1 ± 3.7	7.9
79	"	10.2 ± 2.7	4.1
80	"	48.8 ± 3.6	5.0
81	"	11.7 ± 3.1	1.3
82	Northwestern Dent	4.1 ± 2.2	0.0
83	"	100.0 ± 5.2	12.5
84	"	24.6 ± 3.5	3.1
85	Longfellow	40.0 ± 3.0	22.0
86	King Phillip	53.1 ± 5.4	12.5

Of these 14 selfed lines selected as low smut strains under ordinary field conditions, 6 would be classed as low, 5 as medium and 3 as high smut strains under epidemic conditions. On the basis of this single year's test it may be concluded that selection of low smut strains under natural field conditions is an aid to obtaining smut-resistant strains, but that they should be tested under epidemic conditions in order to be sure of their resistance.

THE INHERITANCE OF A FIRING CHARACTER IN A CROSS OF TWO SELFED LINES OF MINNESOTA NO. 13

A rather striking firing character had been observed and notes taken on it for several years, previous to 1924, in one of the Minnesota No. 13 strains (Culture 15). Other strains growing beside this firing strain were observed to be free from this condition. This firing made itself manifest by a drying up of parts of the leaves, especially at the tips. Long, slender blotches appeared on the leaves and seemed to follow the vascular bundles, indicating an intervascular type of firing. The first symptoms were several times suspected of being due to a pathological condition. Cultures were made but no organism was found. Since chlorophyll abnormalities in maize seedlings often give similar long, slender blotches on the leaves, it is suggested that this condition may be another mature plant chlorophyll abnormality.

The parent line of Minnesota No. 13, culture 15, had 76 per cent of the plants fired in 1921 and all plants fired in 1922, 1923, and 1924. Another parent line of Minnesota No. 13, culture 17, showed no fired plants in 1921

or 1922 and only a few plants fired in 1923. The season of 1923 was very dry, and the drying up of some of the leaves was probably not due to the same genotypic condition that caused the firing in culture 15. No record of culture 17 was available in 1924 because of loss of the strain. These two lines, which also differed in smut reaction, were crossed in 1922. The F_1, F_2, and backcrosses were grown in 1924. Notes were taken on the individual plants, and the degree of firing was classified as heavy, medium or none.

The firing parent had 68 plants heavily fired and 6 plants medium fired in 1924. The observed numbers of plants in the different firing classes, and the numbers which would be expected on the basis that a single factor in the homozygous recessive condition determined heavy firing, in the heterozygous condition determined medium firing and in the homozygous dominant condition determine no firing, are given in table 6.

TABLE 6.—*Observed number of plants differing in degrees of firing, and the calculated number, on the basis of a single factor difference, in a cross between a firing and a non-firing selfed strain*

Cross	Observed or calculated	Number of plants			
		Degree of firing			Total
		Heavy	Medium	None	
F_1	Observed	5	162	4	171
(All × none)	Calculated	0	171	0	171
F_2	Observed	172	333	158	663
(All × none)	Calculated	166	333	166	663
Backcross	Observed	141	170	43	354
(All × all × none)	Calculated	177	177	0	354
Backcross	Observed	26	243	143	412
(None × all × none)	Calculated	0	206	206	412

The F_1 showed a complete lack of dominance, the few plants classed as heavily fired and as non-fired being no more than would be expected from the normal variability of such a character and from the fact that slight errors may have been made in taking notes.

Segregation took place in F_2. The "goodness of fit" method of calculating the deviation from the expected, on the basis of a single factor difference, gave the results shown in table 7.

With $X^2 = .606$, P would be very large and the chances would be very great that the deviation from the expected was due to chance variability.

The deviation in the backcrosses from expectation on a single factor basis was rather large. It is apparent, however, that the condition is not very

complex from an inheritance standpoint, although more than a single genetic factor may be involved.

TABLE 7.—*Comparison by the "goodness of fit method" between observed and calculated number of plants in the F_2 of a cross between firing and non-firing strains*

Degree fired	Number of plants		O–C	$(O–C)^2$	$\frac{(O–C)^2}{C}$
	Observed	Calculated			
Heavy fired	172	166	6	36	.217
Medium fired	333	332	1	1	.003
Non-fired	158	166	8	64	.386
				$X^2 =$	.606

LINKAGE BETWEEN FIRING AND SMUT REACTION

In table 8 is summarized the correlation between firing and smut reaction. The F_1 cross was made in 1922 and the other crosses were made in 1923. All crosses were grown in 1924.

TABLE 8.—*Correlation between reaction to smut and a firing character in crosses between a firing, high smut (70.2%), selfed strain and a non-firing, medium smut (30.0%), selfed strain, 1924*

Type of parent or cross	Fired			Not fired		
	No. Smutted	No. not Smutted	Per cent Smutted	No. Smutted	No. not Smutted	Per cent Smutted
All fired, high smut parent	55	19	74.3 ± 3.9			
F_1 (all fired, high smut × none fired, medium smut)	77	89	46.3 ± 3.4	2	2	50.0 ± 5.1
F_2 (all fired, high smut × none fired, medium smut)	274	231	54.3 ± 5.5	78	80	49.4 ± 3.7
F_1 × all fired, high smut parent	240	71	77.2 ± 4.0	22	21	51.2 ± 5.2
F_1 × none fired, medium smut parent	126	143	46.8 ± 3.5	64	79	44.7 ± 3.3

If there were a linkage between the factors determining firing and those determining smut reaction, it would be expected that the fired plants would

have a higher percentage of smut than the non-fired plants. In only one cross, that of the F_1 with the all fired, high smut parent, was there a significantly higher percentage of smut on the fired than on the non-fired plants. The number of non-fired plants, however, was very small in this cross. In consideration of this and the fact that no linkage was evident in the F_2 or other backcross, it cannot be safely concluded that there is a linkage between the factors determining firing and smut reaction.

SUMMARY

1. The probable error in percentage decreased uniformly as the percentage of smut infection in the paired plots increased.

2. The parent lines developed a uniform percentage of smut from year to year (1922–1924 inclusive).

3. The factors determining resistance or susceptibility were transmitted in the same manner in both male and female gametes.

4. Dominance of resistance or susceptibility to smut reaction was lacking. Further study is necessary before concluding how many factors are involved.

5. Low smut strains of corn selected under normal field conditions should be tested under smut epidemic conditions in order to be sure of their resistance.

6. The inheritance of firing can be adequately explained on the basis of a single factor difference. There was apparently no correlation between smut and firing.

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TWO UNDESCRIBED SPECIES OF BOTRYTIS ASSOCIATED WITH THE NECK ROT DISEASES OF ONION BULBS[1]

J. C. WALKER

WITH TWO FIGURES IN THE TEXT

The neck rot diseases of onion have been the subject of study by the writer since 1917, particularly as they occur in the onion-growing sections in the middle west. In that year Munn (1) published the results of his studies upon a neck rot disease in Michigan and New York, in which report he described a new species, *Botrytis allii*, as the causal organism. This form has been found in the Wisconsin and Illinois sections, and his findings with regard to the morphology and pathogenicity of the organism have in the main been corroborated. It became evident early in the course of the writer's investigations that two other distinct species of *Botrytis* are commonly associated with this disease and one of these forms is by far the most important cause of neck rot in the Wisconsin and Illinois sections. A careful study of the two last forms has shown that they are apparently undescribed species. Since each of the three species causes symptoms upon the host which though very similar to those of the other two forms are nevertheless distinct, it seems appropriate to designate each disease separately. The writer therefore has chosen to speak of them subsequently as (1) the grey-mold neck rot caused by *Botrytis allii* Munn, (2) the mycelial neck rot caused by *Botrytis byssoidea* n. s., and (3) the small sclerotial neck rot caused by *Botrytis squamosa* n. s. The mycelial neck rot causes greatest losses of all three diseases in the Wisconsin and Illinois sections. The small sclerotial neck rot, found so far only upon white varieties, is confined more particularly to the dry outer scales of the bulbs and is therefore least destructive of the three diseases. Certain physiological studies of one or another of the three forms already have been published (3, 4). In these reports the mycelial neck rot form has been referred to as *Botrytis sp. 110*, and the small sclerotial neck rot form as *Botrytis sp. 108a*. The control of mycelial neck rot by artificial curing also has been previously discussed (2). A more detailed discussion of the pathological phases of the three diseases will be published in another paper. Accounts of the two undescribed species are presented at this time.

[1] The writer is indebted to Prof. H. H. Whetzel, of Cornell University, for advice furnished during the preparation of this manuscript.

Botrytis byssoidea n. s. (Fig. 1.)

Mycelium hyaline, septate, variable in diameter, branches sometimes constricted slightly at the base; conidiophores arising directly from the mycelium or from sclerotia, erect, becoming flattened and twisted with age.

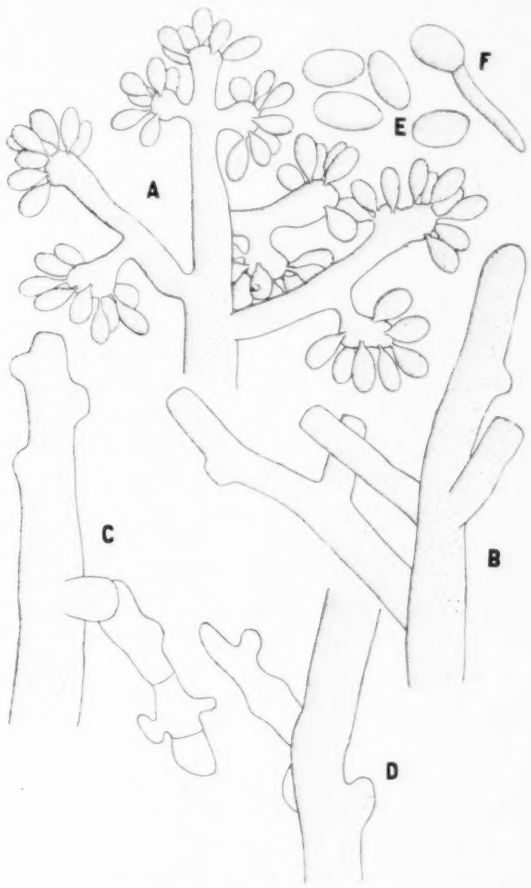

FIG. 1. Conidial production of *Botrytis byssoidea*.

A. Tip of the conidiophore showing characteristic branching and the production of conidia upon short sterigmata which arise from the rounded apices of the branches. B. Tip of conidiophore some time after sporulation; the main stalk is proliferating, while the sporiferous tips of the branches have been cut off by septa and have disappeared; the branches continue to degenerate. C. Conidiophore in which the sporulating side branches have all degenerated, having been cut off by septa near the main stalk and leaving slight projections. D. Remains of sporulating branches on a conidiophore which has proliferated and grown on to produce more sporulating branches at the growing tip. E. Mature conidia. F. Conidial germination in tap water after 20 hours at 20–22° C. ×600.

hyaline at the growing tip, walls becoming deep brown with age, septate, slightly swollen at the base, occasionally branched, branches constricted at the base; hyaline sporiferous branches, formed at the growing tip, rebranch and produce the conidia upon short hyaline sterigmata on their rounded apices; these branches occasionally proliferate, but usually degenerate as soon as the conidia are mature, having been cut off close to the main trunk by septa; the main trunk proliferates and is marked by scars or short projections at the points where sporiferous branches have degenerated. Conidia obovoid, smooth, continuous, hyaline, ashen grey in mass when young, becoming somewhat darker with age; sterigmata not often remaining attached; 8–19 × 5–11 μ (mostly 10–14 × 6–9 μ). Microconidia globose, about 3 μ in diameter, borne upon short, hyaline, conidiophores. Sclerotia white at first becoming black with age; raised and rounded on the upper surface, flat or concave on side in contact with the host, variable in size (1 to 5 mm. or more), irregular in shape, often converging into large conglomerates; in cross section, pseudoparenchymatous, several outer layers of cells dark walled, interior hyaline; germination under favorable conditions by hyaline hyphae or by conidiophores.

Parasitic on bulbs of *Allium cepa*, appearing usually after harvest and infecting usually at the "neck" of the bulbs; distribution, Wisconsin, Illinois, Connecticut, France. Type specimens deposited with Office of Pathological Collections, Bureau Plant Industry, U. S. Department of Agriculture, Washington, D. C.; Herbarium of the University of Wisconsin, Madison, Wis.; and Herbarium of Royal Botanic Gardens, Kew, Surrey, England.

Botrytis squamosa n. s. (Fig. 2.)

Mycelium hyaline, septate, variable in diameter, branches not ordinarily constricted at the base. Conidiophores comparatively rare at 20–22° C., more abundant at cooler temperatures; seldom rising directly from the mycelium, more often in tufts from sclerotia; erect, becoming flattened and twisted with age; hyaline at first, turning dark with age; septate, slightly swollen at the base; branches common and constricted at the base; growing tips branch and rebranch previous to sporulation; conidia borne on short hyaline sterigmata arising from swollen apices of branches and become detached at maturity; side branches degenerate after fructification, the walls drawing back in characteristic accordion-like folds; degenerating side branches cut off by septa laid down near the base, leaving distinct scars or knobs upon the main stalk; main stalks proliferate and sporulate repeatedly depending upon conditions. Conidia obovoid to ellipsoid, smooth, continuous, hyaline, ashen grey in mass when young becoming somewhat

darker with age; sterigmata seldom remaining attached; 13–22 × 10–17 μ, mostly 15–20 × 12–15 μ. Microconidia globose, about 3 μ in diameter, borne upon short, hyaline conidiophores. Sclerotia white at first, turning black with age; most common on dry outer scales of the host, roughly circular in outline, flat, scale-like, 1/2 to 4 mm. in diameter, rarely more than 1/8 mm. in thickness; often converging into large scale-like conglomerates.

Parasitic on outer scales of bulbs of *Allium cepa*, especially upon white varieties; distribution, Wisconsin, Illinois. Type specimens deposited with the Office of Pathological Collections, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.; Herbarium of the Univer-

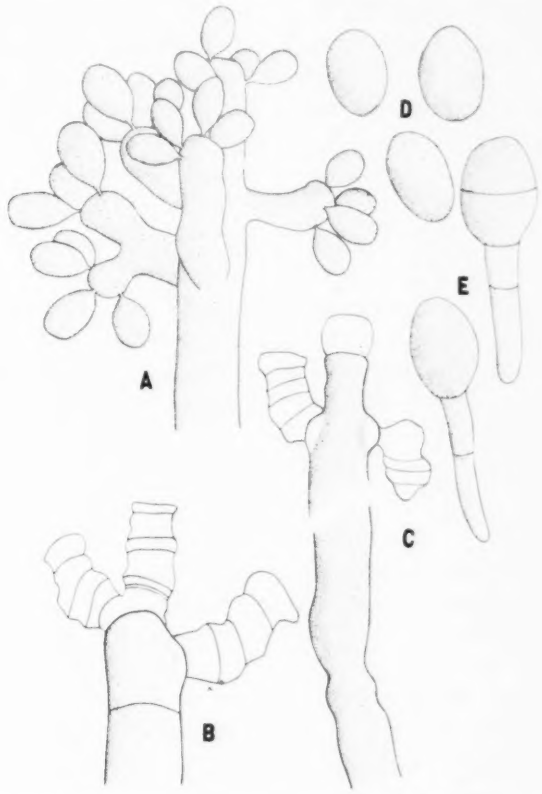

FIG. 2. Conidial production of *Botrytis squamosa;* the process is very much like that of *Botrytis byssoidea.*

A. Sporulating tip of conidiophore. B. Degenerating sporiferous branches which shrink back in accordion-like folds. C. Conidiophore showing degenerating branches at the tip, while lower down are the irregularities left from the previous group of sporiferous branches. D. Mature conidia. E. Conidial germination in tap water after 27 hours at 20–20° C. × 600.

sity of Wisconsin, Madison, Wis.; Herbarium of the Royal Botanic Garden, Kew, Surrey, England.

The three species of Botrytis associated with onion neck rot are very easily distinguished by their characteristic types of growth upon a number of standard cultural media. Inasmuch as this may be used as a ready means of diagnosis, the salient characters of the growth of the three forms upon potato-dextrose agar plates at room temperature are given.

Botrytis allii.

Produces a rapidly growing colony reaching a diameter of about 50 mm. in 4 days at 20–22° C. In the beginning, the center of the colony consists of dense whitish aerial mycelium, while the outer zone of about 5 mm. in width consists of scanty, creeping extending mycelial threads. Conidiophores and conidia appear on about the third day, nearly white at first, turning smoky grey with age. Eventually the entire plate becomes covered with a dense uniform layer of conidiophores. Sclerotia are not commonly produced.

Botrytis byssoidea.

The colony grows somewhat faster at 20–22° C. than does that of *Botrytis allii*. Abundant white, fluffy, aerial mycelium forms which is more raised and cottony than that of either *Botrytis allii* or *Botrytis squamosa;* fairly uniform in density except at the very center where there is little aerial mycelium, and at the narrow outer zone of extending hyphae. Conidia are seldom produced. Sclerotia absent.

Botrytis squamosa.

The colony which enlarges more slowly than either *Botrytis allii* or *Botrytis byssoidea* consists of white fluffy aerial mycelium, except for the outer advancing zone, but it is less raised and fluffy than that of *Botrytis byssoidea*. Abundant sclerotia appear over the entire plate after two to three weeks, first as dense whitish mycelial masses which become hard, and black with age; mostly 1–2 mm. in width and thicker and more rounded on the upper surface than those which develop upon the host. There is very little sporulation at room temperature (20–22° C.) but profuse production of conidiophores arising directly from the sclerotia occurs at 12° to 16° C.

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A NOTE ON THE BROWN LEAF-SPOT OF ALFALFA

L. R. Tehon and Eve Daniels

With One Figure in the Text

During each of the years 1922 and 1923, the collections made by the botanists of the Illinois State Natural History Survey included a few specimens of alfalfa leaves affected by a marked browning which, in its more extensive manifestation, assumed the character of a severe leaf blight. These were set aside under the suggestive label *Macrosporium sarcinaeforme* Cav. In 1924 numerous additional specimens of the same kind were collected from widely separated parts of Illinois. The nature of the diseased spots and the notes accompanying the specimens indicated that the disease was of some importance, and that it was responsible for a considerable loss in the fields in which it was found.

The fact that the fungus has been reported several times as causing severe losses upon red clover in the United States and in Europe suggests that its presence upon alfalfa may constitute another serious impediment to the successful production of that very valuable crop, at least in certain seasons. An account of the disease and of the fungus, as we have seen it in Illinois, should therefore be of interest.

SYMPTOMS

The first symptom of this disease is a marked local yellowing of the leaf tissue. A dead area, brown in color, soon appears, replacing the yellowing which is apparent thereafter only as a narrow band of etiolated tissue marking the advance of the rapidly enlarging spot. Infection may take place at any point on the leaflet, although usually it is marginal. Intramarginal infections are circular and, for a time, quite arid. The extension of the spot is rapid, encompassing, as it spreads, whatever other lesions there may be upon the leaflet. Ultimately much of the tissue is involved.

The older portions of the lesions become dark brown and wrinkled, and eventually appear sooted from the abundant production of spores and hyphae by the fungus.

DISTRIBUTION AND IMPORTANCE

The first collection of the brown leaf-spot in Illinois was made July 14, 1922, in Shelby County, and the second, July 16, 1923, in Bond County—both in the southern half of the state. During the summer of 1924 it was seen in many fields, first in Jersey County, August 25, and last in Carroll

County, September 17. With the exception of the first, all the 1924 records came from the northern half of the state. The accompanying map (Fig. 1, a) shows the counties in which it has been found, and suggests that it is even more widespread. So extensive a distribution here indicates the probability of its occurrence in neighboring states as well. Indeed, Dr. F. R. Jones writes that he has seen this disease occurring extensively in northern states, practically from the Atlantic coast to Minnesota.

Like other leaf diseases of alfalfa, this one causes its chief damage by killing the leaflets and causing them to shatter off, thus reducing the harvestable crop. As observed in Illinois, the attack is general in infested fields, and the damage done is often directly in proportion to the number of diseased leaflets per plant. Table 1, compiled from the 1924 field notes, indicates the ranges of infection observed and shows that the disease may be, under proper circumstances, either very light or very serious. It is significant that in the fields examined the acre-average shows that about 20 per cent of the leaves were infected.

TABLE 1.—*Summary of field notes on the prevalence of the brown leaf-spot of alfalfa in Illinois*

County	Acres	Per cent of diseased plants	Per cent of diseased leaflets
Boone	5	100	33
Carroll	4	100	2
Cook	6	100	1
Jersey	10	100	1
Lake	4	100	75
do	10	100	33
Peoria	2	100	10
Putnam	2	100	25
		Acre-average	20.67

Macrosporium sarcinaeforme was originally described by Cavara (2) from Italy in 1890. The earliest record of its occurrence in the United States is a specimen collected by May Varney (No. 1193) at Manhattan, Kansas, October 12, 1889, on clover. Malkoff (5) records it as a serious leaf blight of clover in Europe. Orton (6) reports that its prevalence upon clover in Connecticut and New York caused comment in 1903, and that (7) it was common in Tennessee in 1905, but subordinate to anthracnose. Bain and Essary (1) record it as being destructive on red clover and occasionally on alsike in Tennessee. The only reference to the presence of the fungus on alfalfa of which the writers are cognizant is one by Westgate (12), who

speaks of it casually in a brief discussion of alfalfa diseases: "Another form of leaf spot (*Macrosporium sarcinaeforme*) is sometimes destructive. This appears in the form of well defined circular spots which show numerous black dots scattered over their surfaces."

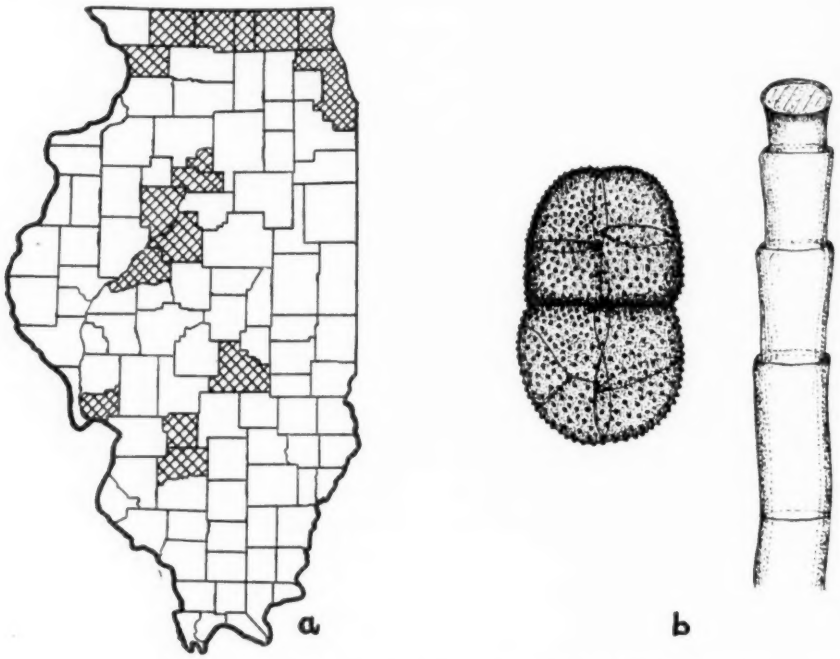

FIG. 1. a. Known occurrence of the brown leaf-spot of alfalfa in Illinois. (Indicated by crosshatched areas.) b. A spore, and the apex of a conidiophore, of *Thyrospora sarcinaeforme*.

TAXONOMY

Comparison of the alfalfa parasite with the Varney specimen and with available exsiccati reveals no striking differences such as would justify specific segregation. As we have seen it, the fungus has upright conidiophores which are either single or grouped in fascicles. The fascicles are not large; rarely are there more than four hyphae. The olive-brown conidiophores are short—much shorter than is recorded in Malkoff's diagnosis of the fungus as it occurs on clover. Their nodulose character, noted both by Cavara and Malkoff, gives them a striking, jointed appearance which seems to result from the continued apical growth of the hyphae following the individual abscissions of successively formed spores.

The spores, which are borne singly upon the apices of the conidiophores, are olive-brown, concolorous, and muriform, with a marked median con-

striction at the heavy lateral septum which divides the spore into slightly unequal halves (Fig. 1, b). The epispore is definitely, but minutely, echinulate. There is considerable variation in size and septation among the spores, but the measurements, both of length and width, fall well within the limits prescribed by Cavara and those observed by Malkoff, while the variation in septation is concerned only with the number of diagonal walls in the spore and not with the lateral septum.

Macrosporium medicaginis Cugini (11) apparently causes a very similar lesion on alfalfa leaves; and the obvious difficulties of specific determination in *Macrosporium* at once raises the question as to whether our alfalfa parasite may not be identical with the one described by Cugini. There can be no doubt that the two are distinct. Cugini's figures illustrate the usual oblong spores of the genus, with the customary type of septation, and show conidiophores made up of pyriform (as the description says) or (more accurately) torruloid compartments. Cugini states that his species approaches *M. meliloti* Pk.; and Traverso adds, in a footnote, that it also approaches *M. globuliferum* Vestergr. Peck's (8) description of his species, while not altogether clear, is definite with respect to the spores, which are "subelliptical, or clavate, generally tapering below into a short pedicel, 3–5 septate with a few longitudinal septa"—a description not in any way applicable to ours, but confirming our belief that we are dealing with *M. sarcinaeforme*. Vestergren's (9) description of *M. globuliferum* speaks of typically 3-septate muriform spores slightly constricted at the septa. These would not be like the spores we have. The "subquadratic" divisions of the conidiophores of *M. globuliferum* are said by Traverso to be one of the points of difference between it and *M. medicaginis*, and he thereby emphasizes a marked distinction between Cugini's species and the one with which we are dealing.

It would appear, therefore, that the fungus we have found on alfalfa in Illinois is identical, so far as may be judged from descriptions and available figures and specimens, with *M. sarcinaeforme*.

The original definition of the genus *Macrosporium* is not sufficiently clear, either as to its wording or with respect to its original species, to permit definitely of the inclusion of sarcinaeform-spored types. Elliott (3) definitely excludes them and suggests that they may be placed in the genus *Stemphylium;* but his suggestion is not applicable to our fungus, since the definition of that genus requires repentiform conidiophores.

Among the Fungi Imperfecti it is a tenable procedure to make distinctions, greater than specific ones, partly upon the character of the epispore; in fact, satisfactory grouping often makes it necessary. Thus, *Macrodiplodia* is separated from several other diplodioid genera by the mucus covering

of its spores. The same is true of *Cylindrocephalum* and *Acontium*. The number of genera separated on the basis of spore ciliation is large. A spiny epispore distinguishes *Roumegueriella* from *Zithia* and related genera, and *Zygodesmus* from three others; verrucose spores separate *Discomycopsella* from *Pirostoma;* and echinulate spores separate *Heterosporium* from *Helminthospora* and *Helminthosporium*.

Species of *Macrosporium* of the type represented by *M. sarcinaeforme* have been excluded from the genus by Elliott because of their sarcinaeform spores. The upright, unbranched conidiophores exclude them from *Stemphylium* also. The minutely echinulate epispore is a character not properly ascribed to either. It seems desirable, therefore, to provide a genus capable of including this and other similar species now incapable of proper generic reference; and for this purpose we are establishing the genus *Thyrospora*, the designation being in accord with the usage of Hoehnel (4) and of Sydow and Werdermann (10) for fungi of similar aspect.

Thyrospora gen. nov.

Dematiacea, dictyospora, macronemea. Hyphis erectis, septatis, singulis aut fasciculatis, coloratis. Conidiis muriformibus, sarcinaeformibus, echinulatis, gestis singillatim, ex apice hypharum oriundis, coloratis.

Spectat ad Thyrodochium Werd., genus Tuberculariacearum. Species typica:

Thyrospora sarcinaeforme (Cav.) Comb. nov.

Syn. *Macrosporium sarcinaeforme* Cav. Dif. dei Parass. 1890.

NATURAL HISTORY SURVEY,
URBANA, ILLINOIS.

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SCLEROSPORA ON CORN IN AMERICA

I. E. Melhus and Frank Van Haltern

Sclerospora graminicola (Sacc.) Schroet. is very common in Iowa and adjoining states on *Setaria viridis* (L.) Beauv. (green foxtail), a prevalent and troublesome weed in corn fields.

This fact led the authors to try infection of corn with the downy mildew occurring on *Setaria*. Having had success in infecting *S. viridis* using oospores on the seed and in the soil, they attempted to infect corn. Infection took place within two days after the spores were placed on the seed under conditions favorable for their germination. Infection was readily obtained on dent, sugar, pop, and flint varieties. Infection takes place before emergence of the plumule from the soil. In many cases ninety per cent of the plants exposed became infected.

The symptoms on *Setaria* and corn are markedly different in some respects. On corn the symptoms are more often a grayish blotching and mottling that may extend throughout the whole plant. In other cases, only a few mottled yellow spots develop, or chlorotic areas occur in the form of longitudinal stripes apparently following between the vascular bundles of the blades.

Mottling may appear as irregular, isolated spots one-fourth inch to several inches long and may often develop quite rapidly in an apparently healthy seedling. Symptoms usually appear within ten days after the plumule emerges, but may not develop for three weeks. This apparently depends upon how soon infection occurs after germination.

Infected corn plants are almost always stunted, depending on the severity of the infection. Some may succumb and die when only three inches tall, while a few appear to outgrow the disease. Many infected plants fail to develop other chlorotic areas after the initial symptoms appear, but become very rich green and have a bushy, stocky appearance, due to the production of the normal number of leaves on a stalk with shortened internodes.

The dwarfing is much like that described by Weston,[1, 2] due to *Sclerospora Philippinensis* Weston and *S. spontanea* L. in the Orient. Conidial sporulation is rather sparse, while oospore production has never been found. Weston[1] also reports that he never found oospores of *S. Philip-*

[1] Weston, W. H. Philippine downy mildew of maize. Jour. Agr. Res. **19**: 97–122. 1920.

[2] Weston, W. H. Another conidial *Sclerospora*, of Philippine maize. Jour. Agr. Res. **20**: 669–684. 1921.

pinensis on corn in the Philippines. Some plants may become quite downy with conidiophores, while others may produce few or none, although showing marked symptoms of the disease. The heaviest sporulation on corn is much less than the ordinary sporulation on *Setaria viridis* and occurs only in the seedling stage. This probably explains why no one has recorded the presence of this disease heretofore.

Soil from a field where the downy mildew was abundant the previous year on *Setaria viridis* was brought to the greenhouse at various times, and infection was secured on plants from foxtail seed planted in the soil and on volunteer plants. It is evident that the oospores overwinter in the soil and infect the germinating seed of foxtail early in the spring. From these centers the fungus may spread by means of the conidia. Experiments indicate that the oospores remain viable in the soil over a long period of time so that succeeding crops of foxtail may be infected from oospores as well as by conidia.

Sclerospora graminicola apparently has a wide host range. It was readily transferred to two varieties of millet, *Setaria italica* (L.) Beauv. and *Panicum miliaceum* L., to Teosinte, *Euchlaena mexicana* Schrad. and to 26 varieties of *Zea mays*. The varieties of pop corn are the most susceptible. Twelve varieties of dent corn were readily infected.

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THE LITERATURE OF PLANT PATHOLOGY AND THE PLANT INDUSTRY CATALOG

NEIL E. STEVENS

So close has been the ecoperation between the library of the Bureau of Plant Industry and the editorial boards of PHYTOPATHOLOGY, and so general has been the use of the facilities of the Bureau by members of the Phytopathological Society that the publication in this Journal of a sketch of the "Plant Industry Catalog" might seem superfluous. The recently retired editor has, however, called our attention emphatically to the increasing danger that important earlier work may be overlooked in preparing papers for publication. One of the best, perhaps the best, means of avoiding this danger is furnished by a good card catalog.

The "Plant Industry Catalog" consists—like ancient Gaul—of three parts, the author catalog, the general botany subject catalog, and the plant pathology catalog. The author catalog was begun in 1903 by Miss Marjorie F. Warner, but since 1906 has been maintained by Miss Alice C. Atwood, who inaugurated the general botany subject catalog. The plant pathology catalog was begun by Miss Oberly some time before 1908, but during 1919, when Miss Oberly was detailed to the Reclassification Commission, Miss Atwood took over the work on the plant pathology catalog and has carried it on since Miss Oberly's death in 1921.

Little need be said about the author catalog. It has no peculiarities of arrangement save that an attempt is made to bring the editions of a work together and also to have translations follow the original work, with cross references from varying titles. Biographical and bibliographical works about authors are included.

The general botanical subject catalog, which covers botany in its widest sense (systematic, economic, geographic, ecologic, morphological and physiological botany, etc.), is a semi-classed catalog, that is, the main headings are in alphabetical order but under these are many divisions and sub-heads. For instance, under IRRITABILITY AND MOVEMENT OF PLANTS are found as sub-heads, *Geotropism*, *Heliotropism*, *Twining of plants*, etc.; the large group FUNGI has many divisions and such headings as *Fungi, Nomenclature*—*Fungi, Edible and poisonous*—*Fungi, Morphology and physiology*, besides a geographic arrangement. The botany of the United States is under the heading UNITED STATES BOTANY, with large subdivisions (*New England*—*Western States*, etc.) arranged under it, followed by the states in alphabetical order. CITRUS FRUITS is used as a general heading with individual

fruits brought out as sub-heads and the same arrangement obtains for SMALL FRUITS, NUTS and many other headings. These are only a few examples of the method of arrangement. Cross references enable one to trace a subject from its alphabetical position to its place in the semi-classed arrangement.

The plant pathology catalog deals with diseases of plants caused by fungi, bacteria, parasitic phanerogams and nematodes; physiological diseases and injuries; and diseases of the mosaic type. Like the general botany catalog, it is semi-classed. The main arrangement is by host, with subdivisions for *Disease resistance*, *Diseases* (in general), *Diseases, Control*, followed by the individual diseases as sub-heads in alphabetical order. Common names are used for the diseases whenever the common name is widely used; if it is not sufficiently well known the name of the organism is used. Besides these, there are sub-heads for diseases not caused by fungi or bacteria such as *Chlorosis, Mosaic, Physiological diseases*, etc. References are made from the name of the organism to the host, as will be shown by examples given below. A fifth subdivision under the host is *Injuries*, under which are included "Lightning injury," "Weather injuries," etc.

The following examples will show the general arrangement under host:

Celery. Disease resistance and resistant varieties.
Celery. Diseases.
Celery. Diseases. Control.
Celery. Diseases. Bacillus apiovorus.
Celery. Diseases. Bacterial leaf spot. Pseudomonas apii.
Celery. Diseases. Cercospora apii see Celery. Diseases. Late blight.
Celery. Diseases. Club root.
Celery. Diseases. Mosaic.

In their alphabetical place in the catalog will be found the references:

Bacillus apiovorus. See Celery. Diseases. Bacillus apiovorus.
Pseudomonas apii. See Celery. Diseases. Bacterial leaf spot.
Cercospora apii. See Celery. Diseases. Late blight.
Plasmodiophora brassicae. See Celery. Diseases. Club root.

Of course there are many other headings in the catalog besides the host names, such as BACTERIAL DISEASES OF PLANTS—PARASITISM AND DISEASE RESISTANCE—SOIL ENVIRONMENT, EFFECT ON PLANT DISEASES—MOSAIC DISEASES—SEED TREATMENT—PLANT DISEASES with many subdivisions and a geographic grouping. These few will serve as examples of a very large number.

The catalog is, of course, still in the process of making. The growth of the catalog is well indicated by the lists of current botanical literature sent out every two weeks by the Bureau of Plant Industry Library, since these lists are compilations of the indexing done for the botany catalog. These lists also serve as an indication of the present rate of botanical publication. Botanical literature has long been so voluminous as to be beyond the power of any one botanist to master or even to read. The examining and cataloging of that portion of it which reaches Washington libraries already taxes the ability of Miss Atwood and her present assistant Miss Colvin.

Some idea of the scope of the catalog may be gained from a statement of its size. Early in 1925 the author catalog contained 130,000 full entry cards. The subject catalog on general botany contained 95,000 cards and that on plant pathology 25,000 cards. This is exclusive of a large number of cross references. Comparison of the Plant Industry Catalog with other botanical catalogs is neither necessary nor desirable. To paraphrase the recently quoted statement of a wise dean regarding his college, we do not claim that it is the best catalog of the literature of plant pathology or even that it is better than others, but we know that it is a good catalog and that it is continually becoming better.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

PHYTOPATHOLOGICAL NOTES

Conference for the study of potato virus disease, Lincoln, Nebraska, December 28, 1925. The Nebraska Agricultural Experiment Station extends an invitation to every one interested in potato virus diseases for a one-day session at Lincoln preceding the American Association meetings. The objects of the conference are: (1) to study the symptoms of virus diseases and combinations of these diseases on different varieties growing in the greenhouse; (2) to arrive at a standard method of describing symptoms of virus diseases; (3) to avoid the duplication of names for the same disease; (4) to acquaint all workers with virus diseases which are already described by other workers but do not occur in their own localities; (5) to discuss the relation of virus diseases to potato seed production. Different investigators will provide plants with typical symptoms of virus diseases and will discuss and compare the symptoms as they appear in the greenhouse with those which they have observed in the field. This should enable every one attending the conference to become more familiar with the symptoms of various virus diseases, to obtain a better comparison of their destructiveness, and to formulate ideas leading to a more uniform system of potato certification.

The International Committee of Phytopathology and Economic Entomology, appointed by the first congress of Phytopathology and Economic Entomology, held in the Netherlands in 1923, has issued a report covering the period of June 30, 1923, to January 1, 1925. Dr. H. M. Quanjer, Wageningen, Holland, is chairman of the committee.

Personals.—Dr. C. H. Kauffman of the University of Michigan will be on sabbatical leave during the first semester of the academic year 1925–26. He will spend the time in the Pacific Coast states. Correspondence will be forwarded from his usual Ann Arbor address.

REPORT OF THE NINTH ANNUAL MEETING OF THE PACIFIC DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The ninth annual meeting of the Pacific Division of the American Phytopathological Society was held at Oregon Agricultural College, Corvallis, June 22–24, 1925, in conjunction with the Northwest Association of Horticulturists, Entomologists and Plant Pathologists. The official summer field meeting of the American Phytopathological Society also was scheduled to meet jointly with the Pacific Division at Corvallis.

A total of twenty-one plant pathological papers was presented at these meetings, most of them before the pathological section, but a few at the joint sessions of the two societies. About twenty plant pathologists representing California, Idaho, Oregon, British Columbia and the U. S. Department of Agriculture attended the meetings. There were approximately one hundred plant pathologists, entomologists and horticulturists in attendance at the joint meetings.

The program closed Wednesday afternoon, June 24, with field trips to the plots where investigations are being conducted on the virus diseases of potatoes and of the bramble fruits.

The 1926 meeting of the Pacific Division will be held at Mills College, Oakland, California, in affiliation with the Pacific Division of the American Association for the Advancement of Science. The date for this meeting has not yet been definitely set, but presumably it will be in late June.

Following is the treasurer's report as of June 30, 1925.

Receipts:		
Advanced from C. W. Hungerford	$65.52	
Dues received to June 30, 1925	16.00	
Total receipts		81.52
Disbursements:		
Expressage	1.11	
Affiliation fee with Pacific Division, A. A. A. S.	5.00	
Stationery, clerical services and stamps	12.12	
Printing programs	8.00	
Total disbursements	26.23	
Balance		$55.29

C. E. Owens,
Secretary-Treasurer.

TITLES AND ABSTRACTS OF PAPERS READ AT THE NINTH ANNUAL MEETING OF THE PACIFIC DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, CORVALLIS, OREGON, JUNE 22–24, 1925

Newer facts concerning the Verticillium wilt of potatoes. M. B. McKay.

Some problems connected with seed treatment of cereals. H. P. Barss.

Resistance to western yellow blight of tomato. C. W. Hungerford.

Progress report upon potato virus disease investigations. C. W. Hungerford and J. M. Raeder.

The virus diseases of potatoes in Oregon. M. B. McKay.

Transmission of mosaics from potato to tomato. M. B. McKay.

A Myxomycete occurring in the smaller roots of beets. T. E. Rawlins.

A heavy infection by a Myxomycete has been consistently observed in the cortical cells of the smaller roots of sugar beets grown in the greenhouse. The most common form of the organism is the multi-nucleate plasmodial stage which often fills the invaded cells. The plasmodium later becomes differentiated into a mass of thick-walled hexagonal spores which presumably liberate zoospores after the death and decay of the host. An Olpidium-like form and a thick-walled resting stage have also been occasionally found in the infected roots, but it has not been determined whether they are stages in the life cycle of the organism. These preliminary studies indicate that the organism is the same as was described by Nemec as *Sorolpidium betae* Nemec. Future studies are planned to determine the degree of infection in beets grown in the field and to determine whether the organism is detrimental to the growth of the host.

A mycorrhizal fungus found in the smaller roots of celery. T. E. Rawlins and E. H. Smith.

A study of the smaller roots of celery plants grown in the delta peat soil of California has shown that they are heavily infected by a mycorrhizal fungus. The fungus is a Phycomycete and is simliar to the mycorrhizal fungus described by F. R. Jones as having been found in legumes and other plants, in that it is confined almost entirely to the cells of the inner cortex. However, it differs from the fungus found in the pea in that the intra-cellular absorbing mycelium consists of a mass of small distinct hyphae, rather than of swollen amorphous haustoria. This difference may, of course, be due to the different host and is insufficient evidence for considering it as a distinct species. Experiments are in progress in an attempt to determine the relationship existing between the celery plant and the fungus. The organism found by Jones has been observed in great abundance in the roots of sweet peas in California.

Tip-burn and "Slime" diseases of lettuce in California. T. E. Rawlins and R. L. McClain.

Lettuce was grown in both adobe and composted greenhouse soils maintained at different moisture contents. It was found that the plants tip-burned earlier and more severely in the soils of higher moisture content. Plants grown in solution culture also tip-burned very severely. These experiments indicate that it is not feasible to control tip-burn by increasing the water supply at the surfaces of the roots. Cytological studies

of tip-burn in its earliest stages show that the first degeneration usually occurs in the cells adjacent to the vessels at the junction of small marginal veins. This indicates a close relationship between the transpiration stream and the degeneration. Numerous fertilizer experiments failed to show any appreciable difference in the development of tip-burn in the different plots. In general, conditions which promote succulence in the plants seem to make them more susceptible to tip-burn. The tip-burned tissues are often invaded by *Botrytis* sp. or by bacteria. These secondary invasions produce very destructive rots, locally known as "Slime."

A rot of the Calimyrna fig in California. P. D. CALDIS.

A rot of the fruit of the Calimyrna variety of figs was observed in 1922 for the first time, and is known under the names soft rot, pink rot, brown rot, stem end or eye end rot. It is also confused with souring. The rot is caused by a form of *Fusarium moniliforme* Sheldon, and occurs only in caprified figs and caprifigs. The spores of the fungus are carried into the fig at caprification time by the caprifying insect *Blastophaga psenes* L. The fungus grows on the bodies of the dead insects and the stigmas of the flowers in the cavity of the fig until ripening time, when it is able to invade the tissues of the fruit. The rot is mostly internal, but if climatic conditions are favorable, water-soaked purple or pink spots may appear on the surface. A red and a white bacterium are constantly associated with the fungus but are not the primary causal agents.

Another apple-tree anthracnose in the Pacific Northwest and a comparison with the well-known apple-tree anthracnose. S. M. ZELLER and LEROY CHILDS.

A perennial canker of apple trees is prevalent in the Pacific Northwest having a known distribution throughout some of the fruit growing districts of British Columbia, Oregon and Washington. This disease has been observed, or specimens of it received, from the Hood River and Willamette Valleys of Oregon, the Wenatchee and Spokane districts of Washington, and the Okanagan district of British Columbia. The perennial character of the canker complicates the control and is apparent in the concentric growth areas which do not occur in apple-tree anthracnose. The acervuli discharge ellipsoid conidia during spring months while the curved conidia of anthracnose are discharged during fall and winter months. The causal organism is a *Glocosporium*, with morphological affinities close to those of the imperfect stage of *Glomerella cingulata* (Stonem.) S. and V. S. A characteristic ripe rot is produced on apple fruit in storage or by inoculation.

Spur blight (Mycosphaerella rubina) of raspberry in Oregon. S. M. ZELLER and ROBT. K. NORRIS.

This disease is widely distributed west of the Cascade Mountains wherever species of *Rubus* grow naturally or under cultivation, providing climatic conditions are favorable. In commercial plantings of western Oregon spur blight occurs on red raspberry (Cuthbert) and loganberry and with less detrimental effects on black raspberry. The greatest apparent damage is to the Cuthbert under the climatic conditions of the Ashland district, where losses at times reach 50 per cent of the normal crop. Bordeaux mixture applied when the new canes are approximately eight inches and again when they are fifteen to thirty inches has given satisfactory control with much more vigorous growth of canes.

Observations on the growth of Armillaria mellea Vahl in culture. HAROLD E. THOMAS.

Experiments of a preliminary nature with pieces of live roots and twigs of various trees, kept moist in culture tubes and inoculated with *Armillaria* with the object of testing them for resistance, gave the following results:

Almond roots and twigs—readily invaded by fungus, growth vigorous.

French pear twigs, roots and twigs of unidentified *Prunus* sp. found growing in "Armillaria spot"—invaded in part, growth poor.

Myrobalan roots, Cal. North. black walnut roots—not invaded.

The results show that the known resistant varieties show resistance by this method. With improved means of sterilizing surfaces the method may prove effective.

Growth of the fungus has been tested on autoclaved material with the following results:

1. Excellent growth in: autoclaved tube cultures of almond, apricot, pear and Cal. Nor. black walnut twigs; also in flask cultures of dried oak leaves, oak twigs, and dried grass, the material being ground and saturated with water before autoclaving.

2. Poor and slow growth in: flask cultures of coast live oak roots (*Quercus agrifolia* Neé) and of blue gum bark; sawdust cultures of valley oak (*Quercus lobata* Neé); mixtures of equal volumes of sand and valley oak sawdust; peat soil.

3. Very poor growth in: sawdust cultures of Douglas fir; cultures of equal volumes of sand and fir sawdust, soil and fir sawdust, and soil and valley oak sawdust.

4. Practically no growth in ordinary greenhouse potting soil.

5. No growth in sphagnum moss.

The green muscardine fungus (Oospora destructor (Metschn.) Delacroix) on European earwig and other insects in Oregon. H. P. BARSS and H. C. STEARNS.

A fungous disease apparently identical with the green muscardine of Europe has been collected repeatedly at Portland, Oregon, on European earwig and other insects both outdoors and in the insectary of the State Board of Horticulture. The morphological characteristics of the fungus correspond with those given by Delacroix and Vast for the European fungus *Oospora destructor*. It has been readily brought into pure culture. Artificial infections of healthy earwigs with these cultures were successful and reisolations have been made from the insects thus killed. Abundant moisture seems to be necessary to bring about infections and there seems to be little reason to expect the fungus to assume any very important role in the biological control of the earwig under the climatic conditions prevailing in the Pacific Northwest. The fungus produces a white mycelial outgrowth from between the segments of the insects. As the conidia form the color changes to a glaucous green.

A Tubercularia canker of Chinese elm. C. E. OWENS.

A canker disease of the Chinese elm (*Ulmus pumila* L.) was brought to the writer's attention in May, 1925, by Mr. J. L. Mielke, a forestry student, who found the disease developing on a small planting of these elms in the nursery maintained by the school of forestry on the campus of Oregon Agricultural College. An examination showed several trees completely girdled and in a dying condition. The conidial stage of a fungus was fruiting abundantly on the surface of the cankers. This proved to be a species of Tubercularia which, microscopically, seems to be identical with the imperfect stage of *Nectria cinnabarina*. Only the imperfect stage of the fungus has thus far been observed. In all cases examined the fungus seems to have entered at pruning wounds, but once in it acts as a virulent parasite, soon girdling and killing trees which otherwise seem perfectly healthy and vigorous.

Center Rot of "French Endive" or Wilt of Chicory (Cichorium intybus L.) D. B. SWINGLE.

There is a marked increase in the production of French Endive, which in the past has been extensively imported from Europe. Many places in the northern United States are well suited to the production of this vegetable, which is in strong demand during the winter season.

Difficulty has been experienced with endive rots which are under investigation at the Montana Agricultural Experiment Station. These are found to be of two types: "Center Rot" affecting chiefly the young inner leaves, and superficial rots beginning usually on the older leaves. In cultures from leaves affected with the center rot, two species of organisms have been repeatedly found. On re-inoculation each of these is capable, independently of the other, of producing the regular symptoms of center rot, which is characterized by a yellowish olive color. Both failed to attack beets, carrots, cauliflower, cucumbers, potato and turnips, and gave doubtful, probably negative, results on head lettuce and celery. These are described and named as two species, *Phytomonas cichori* and *Phytomonas intybi*. Both are non-spore-forming rods with polar flagella, gram negative, indol negative, not hydrolyzing starch, with a thermal death point of 51°. *Phytomonas intybi* liquifies gelatin and reduces nitrates with nitrogen gas, while *Phytomonas cichori* does not liquify gelatin or reduce nitrates.

An obscure new disease of the strawberry in California. A. G. PLAKIDAS.

The productiveness of the strawberry plantations of the Central California coastal region, and especially of the Watsonville district, has been on the decline for a number of years. This decrease has been attributed by the growers to various causes, but chiefly to degeneration or "running out" of varieties. The first pathological description of a specific disease, known locally as "Strawberry Blight" was given by Prof. W. T. Horne in 1922. (Rept. of the College of Agr. and the Agr. Exp. Sta., University of California, 1922, pp. 121–123). This disease is now widely spread in the Santa Clara and Pajaro valleys, and has been found in other sections of the state—Fresno, San Joaequin, Monterey, Sonoma, and Shasta counties. The most conspicuous symptoms of the disease are: yellowing of the leaves on the margin and between the large veins, with a characteristic curling of the leaves; dwarfing of the leaves, and consequently of the entire plant; the roots of the affected plants apparently remain healthy. The affected plants usually do not die (except in rare instances where other unfavorable factors may enter in), but they remain permanently stunted, and all runners (stolons) arising from a diseased plant are, and continue to remain, diseased. The disease does not seem to be due to malnutrition, for it occurs on all kinds of soil and under the best cultural conditions. Affected vines, transplanted to rich, well manured soil did not recover. The disease apparently is not transmissible through the seed, for seedlings obtained from seed from diseased plants are healthy. No organism has been found so far to be associated with the disease. The infection spreads very rapidly. The disease has many of the characteristics of mosaic or degeneration troubles. Some preliminary experiments, carried out by Professor W. T. Horne, in an attempt to transmit the disease by inarching leaves and runners between healthy seedlings and diseased plants gave inconclusive results. It is believed that the infectious principle is transmitted from diseased to healthy plants by insects. The red spider (*Tetranychus telarius* Linn.) and the strawberry aphis (*Myzus fragaefolii*) are strongly suspected as being the carriers. Experiments to determine this are now in progress. Photographs and exsiccatae illustrating the disease were shown.

An unusual vascular browning of potato tubers as a result of frost. J. W. EASTHAM.

As a result of a severe frost which cut the tops, the last week in September, Burbank potatoes in the Courtenay District showed a browning in the vascular system accompanied by phloem necrosis. This necrosis unlike typical frost necrosis was confined with great uniformity to the vascular "rings" superficially resembling wilt rather than frost necrosis. Field observations also suggest that a succession of temperatures verging on freezing but not low enough to actually cut the tops may bring about net necrosis of the tubers in the Burbank variety. A case of "black heart" was also observed in potatoes which had been exposed to freezing temperatures. About 12 per cent of the tubers were so badly frozen that they collapsed. After sorting and sacking, the remainder were stored with good ventilation and not exposed to heating. About 8 per cent developed well marked "black heart." Potatoes of the same variety not exposed to freezing temperatures stored under identical conditions did not develop "black heart."

The control of core break-down in pears. HENRY HARTMAN.

Core break-down is essentially a disease affecting the core area of pears. It is generally a storage trouble, making its appearance as the fruit approaches prime eating condition. Thus far, it has not been possible to attribute core break-down to the work of a living organism. Although the disease is more serious in some localities than in others, it is more or less common to all pear regions. The development of core break-down is undoubtedly closely associated with time of picking. In all the tests and observations made, only the fruit harvested after its best picking time became affected. The amount of disease that ultimately develops does not seem to be influenced by either the kind of storage or by the length of the storage period. The pressure tester already described in the literature of the Oregon Station (Ore. Sta. Bul. 186 and 206) again proved to be a reliable indicator of maturity in pears, and at this time appears to be the most effective weapon in the control of core break-down. This disease has generally been controlled and pears have developed good quality when picking has been done within the following ranges of pressure: Bartlett, 35 to 25 pounds; Anjou, 24 to 19 pounds; Comice, 20 to 18 pounds; Winter Nelis, 28 to 24 pounds; Willamette Valley Bosc, 30 to 27 pounds, Rogue River Bosc, 24 to 20 pounds.

A bean disease caused by the virus of sugar beet curly-top. EUBANKS CARSNER.

A severe epidemic disease occurred in the bean crop of Twin Falls County, Idaho, in the spring of 1924. A description of the symptoms by a lay observer indicated that the disease was of the mosaic type. The time and locality in which the epidemic occurred suggested the possibility that the leafhopper, *Eutettix tenella*, which transmits the virus of the curly-top disease to sugar beets, might be responsible for the bean disease. Seed were obtained of the important bean varieties grown in southern Idaho and two of these varieties were grown in the greenhouse and inoculated with curly-top virus. The bean plants on which viruliferous leafhoppers were caged developed marked symptoms of the disease—general dwarfing and leaf distortion. The plants on which nonviruliferous leafhoppers were caged continued healthy. The virus was recovered from the diseased beans and effectively transmitted to healthy sugar beets by means of nonviruliferous leafhoppers. The greenhouse inoculations indicated a difference in susceptibility to the disease between the two bean varieties. Field inoculation trials are now in progress with seven varieties of beans in the effort to get further evidence as to variation in susceptibility or resistance. Further investigation will be necessary

to definitely determine whether or not the bean disease in southern Idaho is caused by the curly-top virus.

Preliminary reports on transmission of dwarf of loganberry. S. M. ZELLER.

Aphids originally obtained from *Rosa rubiginosa* L. were allowed to feed for several days on succulently growing loganberry plants affected with the dwarf disease (PHYTOPATHOLOGY **15**: 125. 1925) and were then transferred to the young leaves of healthy loganberry plants grown under cages. Slight or severe necrosis along the veins and margins of the leaves resulted within six days and all growth since this necrosis appeared has exhibited the symptoms of dwarf which are usually observed in the field. When aphids from the same source were transferred from healthy loganberry plants to healthy loganberry plants, the latter have had no symptoms of the dwarf disease.

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